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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

HIGH EXPLOSIVES IN NAVAL WARFARE.

By P. R. ALGER, Professor of Mathematics, U. S. Navy.

I.

One who gives the matter any consideration must be struck by the fact that the effects of high explosives are greatly exaggerated, not only in the popular mind, but almost universally. The idea that such public buildings as the Capitol at Washington, and the Houses of Parliament at London, can be destroyed by the explosive carried on the person of an anarchist, can hardly gain the credence of an intelligent man, although such is the apparent belief of many newspaper writers, but the equally unfounded idea that a battleship can be destroyed by a high explosive shell meets with common acceptance. I have heard officers of our own navy argue against the building of large armored vessels on the ground that the coming use of high-explosive shell will render them worthless, and the Navy Department is deluged with letters from all over the country, and from abroad, proposing schemes for firing high explosive shell, the writers invariably claiming that a single shell on their system will destroy an enemy's ship. Moreover, this opinion is appar-

ently held by numerous writers of authority. For example, Mr. H. W. Wilson, in his interesting book, "Ironclads in Action," says, referring to the dynamite cruiser Vesuvius: "The perfecting of the pneumatic gun would be the death-knell of the battleship, and it is hard to see what protection could be devised against its bolts." The same writer speaks disparagingly of the use of above-water torpedoes on cruisers, considering them a greater danger to the vessel carrying them than to her opponent, and that this view is quite generally held in our navy is shown by the outspoken statements of commanding officers and their requests, in some instances, to the Department, for permission to have the torpedoes removed from the vessels under their command.

Under these circumstances I have thought that it might be of interest to present to the readers of the Institute the conclusions which I have formed in regard to the value of high explosives in naval warfare, though I fear that these opinions are too contrary to those commonly held to command ready acceptance.

In the first place, it is well to try to form a clear idea of just what an explosion is, and, for our practical purposes, we may properly say, that an explosion is the sudden conversion of a solid or liquid substance into gases of high temperature. But there are different orders of explosion, depending entirely upon the rapidity of this conversion. If you set fire to a mass of gunpowder in the open air it explodes, but the process of its conversion into gases is so slow that before it is completely consumed the gases have expanded and occupy a much larger volume than did the original powder. If, on the contrary, you detonate a block of guncotton by means of fulminate of mercury, you thereby instantaneously convert the guncotton into gases which, having no time to expand during their formation, occupy only the same volume the original solid did. In each case the process is the same, but the difference in the time element produces a vast difference in effects. The explosion of low order, such as that of gunpowder, producing an effect like a push, where the explosion of a high order, such as the detonation of guncotton, produces an effect like a blow on the immediately surrounding objects. Now what we mean by a high explosive is an explosive which can, by proper means, be detonated, or instantaneously, before it has time to expand, converted into

gases, and a very important question to consider is, how do the effects of such high explosives, when detonated, compare with the effects of gunpowder?

First, however, let us see what other differences exist between high explosives and gunpowder, besides the peculiar capacity of the former to be detonated, and, also, what differences there are between the principal high explosives themselves which have led to the unanimous selection of guncotton for naval uses.

In what follows the term density of charge refers to the ratio between the weight of an explosive and the volume of the space in which it is contained. If an explosive occupies a space which an equal weight of water would just fill, it is said to have a density of charge of unity, or since 27.73 cubic inches of water weigh one pound, we say that the density of charge is one when the explosive occupies a space of 27.73 cubic inches per pound. If there be 4×27.73 cubic inches, or 110.92 cubic inches, to each pound of explosive, we say the density of charge is $\frac{1}{4}$, etc.

Now, gunpowder burned in a closed chamber at a density of charge of $\frac{1}{10}$ gives a pressure of 10 tons per square inch, while guncotton burned at the same density, by reason of the much greater volume of gases produced, gives 39 tons per square inch, and at a density of charge of unity, while gunpowder gives 42 tons per square inch, guncotton, if contained in an unyielding chamber, would give over 400 tons per square inch. But it has been proven experimentally that the products of detonation do not differ sensibly from those of simple combustion in a closed vessel with high density of charge. Moreover, experiments have shown that the velocity of propagation of detonation is about 1000 meters per second for nitroglycerine, 3000 to 4000 meters for dynamite, and 5000 to 7000 meters per second for guncotton. Imagine, then, a cubic foot of guncotton, having a density equal to that of water, detonated by a fulminate capsule placed on its top. In $\frac{1}{20000}$ part of a second from the beginning of the resulting conversion of the cubic foot of solid into gas, it will have all been converted into gas, which, before it expands, exerts a pressure of over 400 tons per square inch in all directions. Such an enormous pressure must evidently produce the deformation, rupture, and pulverization of materials placed in contact with the explosive. No containing vessel could possibly be made to resist guncotton deto-

nated in its own volume, unless the weight of the explosive were so small that the surface in contact with it conducted off its heat rapidly enough to prevent full development of its explosive force. Of course, as its volume is diminished, the surface of the chamber would have a greater and greater ratio to the weight of explosive it contained, and consequently would more and more decrease the force of the explosion by the absorption of its heat, but the effect of the detonation of any reasonable quantity of guncotton in a closed chamber of its own volume, must inevitably shatter and pulverize the containing walls. With gunpowder, on the other hand, there is no difficulty in constructing containing vessels which it cannot rupture, as instanced by our armor-piercing shell, which have to be loaded with a more powerful explosive than powder in order to be burst.

The difference, then, between detonated guncotton and exploded gunpowder is not only in the instantaneous conversion into gas of the first and the comparatively slow conversion of the latter, but also in the greater volume of gas given off by the former. One pound of gunpowder produces 7740 cubic inches of gases at atmospheric pressure and 0° C., while one pound of guncotton produces 23,810 cubic inches of gases, or three times as much, under the same conditions, about 14 cubic feet against about 4½.

Comparing guncotton with nitroglycerine, next, we find the latter somewhat the more powerful, giving off a less volume of gases, but at a higher temperature, and also, on account of its higher density, being capable of confinement in smaller space than an equal amount of guncotton.

Guncotton, however, is much preferable for naval use to nitroglycerine, dynamite, or any other of the high explosives, on account of its stability and safety in the wet state, and the fact that it cannot be detonated except by fulminate of mercury. Most high explosives, and especially nitroglycerine compounds, can be detonated by shock or heat; guncotton cannot be. It can be set on fire; though, when wet, this is almost impossible, but it only burns freely unless strongly confined. If confined and set on fire, of course the pressure rises until the surrounding walls yield, and if they are strong, an explosion is the result, but numerous experiments have shown that for the detonation of guncotton nothing but fulminate of mercury will serve. When

wet, guncotton of good quality will keep indefinitely, with absolutely no change in characteristics. In this state, or when frozen, it can be detonated by the use of a primer of dry guncotton which is itself detonated by fulminate. No other means of detonating wet or frozen guncotton than by this combination of dry guncotton and fulminate has yet been found. Moreover, when wet, guncotton is almost completely inert.

That it is possible to explode wet guncotton under peculiar circumstances we have abundant evidence, but it is only under special conditions that this can occur, and as these are well set forth and explained in the Report of Her British Majesty's Inspector of Explosives in 1881, I shall quote from them as follows:

"It may at first sight appear remarkable that an explosion of wet tonite should be possible. But apart from the well-known fact that guncotton (of which tonite is only a variety) is frequently employed in the wet state, the initiative explosion being established by a detonator and small primer of dry guncotton, we have the evidence of a not inconsiderable number of accidental explosions of this class of material in a wet state as evidence that such accidents are possible.

"In 1878 no less than eight explosions of wet tonite during pressing occurred at these works; in 1879, there was another similar explosion, and another in 1880, and there have been four (exclusive of the present one) during the present year.

"Then we have had two accidents at the Government Factory at Waltham Abbey—one in 1873, and one in 1877; one at the Royal Laboratory, Woolwich, in 1875; and the ignition of a wet guncotton slab while sawing at the same place in 1877. There were also at one time not unfrequent accidents of this sort at Stowmarket; and from some documents which have been furnished to me through the courtesy of M. Maurouard, Inspector-General of 'Poudres et Salpetres' in France, it appears that three explosions have occurred during the pressing of wet guncotton at the factory at Moulin Blanc, viz.: on the 4th September, 1878; 11th July, 1879; and 8th September, 1879.

"All these accidents may no doubt be referred to the same primary cause, although brought about perhaps in different ways in each instance. On this subject, I will quote the explanation which we offer in our Annual Report for 1878, in special connection with the eight wet tonite accidents of that year—

"'This cause may be stated to be that some small portion of the guncotton is, during the process of pressing or sawing, exposed to the heating, and, therefore, drying influence of friction or pressure. If the friction or pressure be of such a character, or be so maintained upon any portion of the guncotton, as to dry the particles upon which it is exerted sufficiently to render them inflammable, the continuing friction or pressure will, as the next step, establish the actual inflammation of the particles. In the case of the guncotton which took fire in the process of sawing, it is reasonable to suppose that some dry or nearly dry guncotton sawdust had accumulated under the bed of the saw, or in the immediate neighborhood of the point where the inflammation became first established, and this, in its turn, caught fire and produced the accident. In the cases of accidents in the pressing of wet guncotton, whether in hydraulic or steam presses, or in the charging of a shell, if we once assume an ignition of a particle, the resulting explosion can be easily accounted for. The heat generated by the burning of the ignited particles would gradually dry the contiguous portions, and the inflammation would extend with progressive energy until the pressure of the accumulating gases overpowered the resistance of the press, or shell or piston, and (in the absence of some safety-valve or easier method of escape) determined the violent disruption of the containing case. As to how the undue friction becomes first established, that is a point which would have to be determined for each case separately. It may arise from two metal surfaces with only particles of guncotton between them bearing upon one another, in consequence of some defect in the original construction of the machine or tool, or from failure in their application; or, it may be due to the presence of some grit or other rigid substance upon one of the metal surfaces with only a small portion of guncotton interposed. But however the accident may originate in each particular instance, it is, we believe, beyond a question that the rationale of such accidents is to be found in the explanation which we have given above. And it is important to call particular attention to this class of accident and nature of risk, because there is too common a tendency to assume that so long as substances of this sort are wet, nay, that even if they have been at any time wetted, they remain harmless until they have been formally dried, and thus precautions which would

certainly not be neglected with the dry explosive are deemed unnecessary so long as the material is in what is assumed to be a damp condition, while arrangements which may be necessary for preventing any portion of the inflammable substance from resuming its inflammable condition during the operations of manufacture are overlooked or disregarded.'

"It will be observed that this explanation involves no suggestion of a detonative explosion having occurred, it simply assumes inflammation first of one particle and then in very rapid succession of other particles, and when such inflammation becomes established under pressure and the gases are unable to escape, an explosion is not only a natural but a necessary consequence. Where, as in the case of the slab of wet guncotton which ignited during sawing, the gases resulting from this inflammation are free to escape, the result is confined to ignition only and does not proceed to explosion."*

The foregoing quotation is important because of the very common belief, especially among those accustomed to the handling of guncotton, that it will stand anything if wet. It is true that *wet* guncotton can only be exploded by the combined use of dry guncotton and fulminate; it cannot be set on fire even, while wet—*but* it must never be forgotten that it is possible to dry and then explode guncotton by a single action. For example, wet guncotton will stand almost any pressure slowly applied, but apply a very high pressure very suddenly, and the resulting heat may first dry and *then* explode it. It is also important to point out that there is a great difference in guncottons with different percentages of moisture. For instance, guncotton containing 15 per cent of water or less can be detonated by fulminate of mercury alone, but if it contains 18 per cent or over, it requires a dry primer as well as the fulminate. Again, perfectly dry guncotton will be detonated with certainty by 2.83 grains of fulminate in close contact with it, but if only atmospherically dried, it takes 5 grains for certain detonation.

* It was not long after the writing of this paper that the explosion of several pounds of guncotton saturated with water, while being pressed into a 12-inch shell at Dupont's Smokeless Powder Works, resulted in the lamentable death of that accomplished ordnance officer, Capt. Sidney Stuart of the U. S. Army.

Other interesting facts about guncotton are the following:

A dry primer detonated in close contact with wet guncotton will detonate any quantity of the latter, however large and however wet. Saturation, instead of lessening, seems to increase the effect of detonated guncotton. No increase of violence can be obtained by increasing the quantity of fulminate or of dry guncotton. A mass of wet guncotton will have just as great an effect when exploded by a 3-ounce dry primer and a 3-grain fulminate igniter, as if 10 pounds of dry cotton and 100 grains of fulminate were used to initiate the detonation. Close contact, however, is essential when such small quantities are used; the 3 grains of fulminate must not be separated from the dry cotton by more than the very thinnest film of metal, and the dry cotton must have the same close relation to the wet guncotton. No confinement of either wet or dry guncotton is needed for detonation, nor does confinement add in the least to the violence of their explosion when detonated.

Guncotton then, on account of its good qualities, having been adopted by all nations as the high explosive for naval warfare, we have to consider to what uses it is put and whether it can advantageously be used in other ways.

Undoubtedly, in its present use for torpedoes and for destroying obstacles of all sorts, it is much superior to gunpowder. As a submarine mine it will do the work of twice or three times its weight of gunpowder, and by means of two or three small blocks of it, heavy chains, steel rails, booms or other similar obstructions, can be cut in two, where they would be uninjured by large powder charges. But there is one use for high explosives in naval warfare which is not yet developed, but upon the development and towards the introduction of which into general use thousands of people, mostly cranks, but still many intelligent and sensible people, are laboring. I refer to the use of these explosives as the bursting charge of shells, and it is especially to the consideration of whether or not such shell would be more effective than the projectiles in present use, and, if so, how much more effective, that I shall now ask your attention.

What has already been said has shown the first and fundamental difference between the effects of detonated guncotton and of exploded gunpowder in ordinary iron or steel shell filled with them. In the first case, the shell is much more completely

shattered and its small pieces are propelled with greater velocity than in the second case. It is this action which makes the shell or bomb containing high explosive so destructive when detonated in a crowd of people; there are so many more pieces than would be given by a powder-exploded shell that more people are killed or wounded.

But granting the fact that the high explosive produces a much more destructive effect upon materials in close contact with it, we have to consider how its action upon its less immediate surroundings compares with that of powder. The following experiment, made at the N. P. G., illustrates this point. Two similar wooden chambers were built, each 10 feet square and 8 feet high, with 6-inch timber posts at corners, sunk 2½ feet in the ground; other 5-inch posts at the middle of the sides, also sunk 2½ feet in the ground; cross-timbers at top, bottom and middle of these posts and secured to them by 6-inch iron spikes, and sides and top from 2 inches to 3 inches thick securely nailed to the framework. In one of these a 4-inch forged steel shell filled with 2¾ pounds of shell powder was burst, and in the other a similar shell filled with 1.9 pounds of guncotton. In each case the shell was placed on a block of oak 1 foot square and 2 feet 7 inches long, in the center of the floor of the chamber; a square yard of cotton sheeting was hung on the wall 5 feet away, and an old sheepskin sponge head was placed 6 feet above and directly over the shell. The result of the powder explosion was as follows: The oak block had a small dent where the base of the shell stood; the cotton sheeting took fire; part of the wool was blown off the sponge head but not set on fire; the chamber itself was badly wrecked; its rear wall was forced outward bodily and pierced with five holes; the three sides and door were blown out and badly splintered, some pieces being blown 25 feet away; the heavy door was blown 10 feet away and fell on its face, pierced in two places; the sides were badly splintered and broken up, many planks showing marks of small pieces of shell; the front half of the heavy roof was lifted and fell on top of the rear half, one plank being lodged in a tree near by; the largest piece of the shell found weighed 4 pounds; some pieces struck the roof, and had the building stood it was evident that the dispersion of fragments would have been found to cover a large area in all directions.

The result of the detonation of the guncotton shell was as fol-

lows: The oak block was split; nothing was set on fire; the chamber was but little damaged; there was one hole in the roof; the back was blown outward bodily, as in the powder explosion, and had 17 small holes in it; one side had a piece 4 x 7 feet blown out of it, pierced by 4 holes, and its remaining area had 14 holes in it; the front was pierced by 19 holes; a small panel in the door was either blown out or carried away by a fragment; the left side was pierced by 12 holes.

Thus we see illustrated the peculiar difference in effect of the two explosives—the guncotton produces much more violent local effects; breaks the shell into more numerous fragments, and projects them with greater velocity; but its racking effect is much less than that of the powder; the energy of the high explosive is much the greater; but it expends itself largely in rending and shattering materials in close contact with itself.

There would not, then, seem to be any special advantage to be gained by the use of a high explosive as the bursting charge of common shell of small caliber. In order to detonate such shell, fulminate igniters are absolutely necessary, and if wet guncotton is used, a dry primer is also necessary. It is evident, on the face of the thing, that of a shell containing a high explosive coupled with a detonator of five or more grains of fulminate of mercury is a much more dangerous article to handle and fire than is an ordinary powder shell, and to justify the use of the former in place of the latter, considerably greater destructive effect must be demonstrated. But this does not exist under ordinary circumstances of naval warfare. The high explosive shell of small caliber, if fitted with an ordinary detonator, will explode harmlessly outside a ship's plating, or, at the best, after partly penetrating it, in which latter case a great part of the fragments would be harmless. If, on the other hand, fitted with a delayed action detonator, which is perfectly feasible, and made strong enough to penetrate moderately thick plating, the capacity of the shell is thereby reduced and the small quantity of high explosive which it contains will be unlikely to cause any greater damage than would result from the same shell filled with powder; if it burst in a group of men, it will probably injure more, but its general effect will be less. It is important to understand in this connection, that if a shell is not strong enough, or has not energy enough to get through plating, the

fact that it detonates on impact will not add, but rather will detract, from its effect. For example, there were fired several years ago at the N. P. G. a number of 6-inch guncotton shells, and one of them against a 7-inch armor-plate. The plate, which was of nickel-steel, was set up on edge and supported by timber struts from the rear, being very much less strongly held than it would have been on a ship's side. The shell, weighing 78 pounds and containing 12 pounds of guncotton, including the dry primer, struck about 2 feet from bottom and 3 feet from edge, where the plate was 6 inches thick, with a velocity of 1225 f. s., and detonated on impact, being broken into innumerable small fragments. The plate itself was neither knocked down, cracked, nor injured in any way, except for a few scratches and a slight depression made by the point of the shell. In fact, I was satisfied at the time that an empty cast-iron shell with same striking energy would have done fully as much damage, and probably more.

We may conclude, then, at least as far as shell of small caliber are concerned, that to be of any real value in naval warfare, they must be strong enough to go through the plating they are likely to be fired at, and that, if so, their destructive effect would be but very slightly, if at all, increased by loading them with a high explosive, instead of with ordinary black powder.

When, however, we extend our inquiry to the field of large-caliber shell, and especially such shell as are designed to carry very large quantities of high explosives, we are met by the fact that this field is but ill-explored. Almost nothing is known of the effects of such shell, and it has been hitherto almost wholly from the study of the results of accidental explosions that we have been able to judge them. Now there are two theories, so to speak, upon which the use of high explosives, as the bursting charges of large shell, may be advocated. You may say: although it is desirable, viewing the extent to which ships are covered with armor, to make all large-caliber shell of sufficiently thick walls to at least penetrate the thin armor, 4-inch, 5-inch or 6-inch, of an opponent, still the effect of such shell, loaded with a high explosive, will be vastly greater than if loaded with powder. Or, second, you may say: let us not try to pierce the armor of an opponent, but rather let us throw against him such huge masses of high explosive that he will be destroyed

by their detonation; his sides blown in and his crew killed by the concussion. The second of these is, of course, the theory usually held. To combat the first theory we must show that to substitute 20, 30 or 40 pounds of high explosive with a detonator, for about an equal weight of gunpowder, will not cause any marked increase in the destructive effect of the explosion of a large-caliber, thick-walled shell. To combat the second theory, we must show that the effects of the detonation of 200, 300 or even 400 pounds of a high explosive on the outside of a ship, would be by no means so terrific as is usually imagined.

Let us see, first, what past experience can tell us of the effects of the explosion of moderate quantities of high explosives.

On February 26, 1884, an infernal machine, containing 21 pounds of dynamite, about the equivalent of the same weight of dry guncotton, was detonated in the baggage-room of Victoria Station, at London. This station was a wooden structure, with light wooden partitions, and was very much damaged, especially in the vicinity of the place of explosion, but the local effect is well illustrated by the fact that the brick wall of the London, Chatham and Dover Station adjoining was uninjured. This wall, 18 inches thick, was separated 2 feet 4 inches from the light wooden side of the Victoria Station, and the explosive was about 3 feet inside the latter station, so that it was only from 5 to 6 feet from the brick wall. Similar infernal machines had been placed at the same time in the Charing Cross, the Paddington, and the Ludgate Hill stations, but they all failed to explode.

On March 15, 1883, an infernal machine containing, probably, 28 pounds of dynamite, was exploded at the Government Offices in Whitehall, London. The explosive had been placed on the sill of a window, inside the stone balustrade of a room near the center of the basement floor of the building, which is 4 stories high and of about 280 feet front. Practically all the windows over this whole front were broken by the concussion, but the serious damage was but slight. The official report says: "But the structural effects of any importance were, it will be observed, of an essentially local character, having, in fact, been limited to the room and balustrade where the explosion occurred; to some slight cracking of the masonry above and on either side, and to the injury to the floor of the room immediately above.

If the intention was 'to blow up' the Government Offices, the result fell almost ludicrously short of the conception."

In 1884 Commander Folger made a series of experiments at the N. P. G. to determine the effects of high explosives against the sides or decks of ships. The following are extracts from his report on the subject. First, as regards the explosion of dynamite against vertical plating:

"In this experiment two targets were used. The first consisted of nine 1-inch wrought-iron plates secured by nine 1-inch bolts to 20 inches of live-oak backing, which last was well braced in the usual manner.

"This target did not by any means represent in its capacity for resistance the side of a modern armor-clad, the plating being laminated, and the separate sheets greatly weakened by numerous perforations. They had been manufactured as flooring plates of a monitor's turret, the holes serving for purposes of ventilation. The bolting, also, was defective, being insufficient in quality, in weight, and of poor material.

"Two hundred and sixty-five pounds of dynamite were exploded in close proximity and in contact with this target in ten successive charges, varying in weight from 5 pounds to 75 pounds.

"The injury done the target was hardly noticeable after 70 pounds had been exploded at the same point in six successive charges, and was limited to an inappreciable indentation of the plating, the rupture of one bolt at a defective weld, and a slight springing back of the structure.

"With the 50-pound charge the indent deepened to 3 inches with a diameter of 2 feet 6 inches. Five bolts were broken, and the plates bending forward were slightly separated at the edges.

"With the charge of 75 pounds (in contact, as were all charges above 20 pounds), the indent was deepened to 7½ inches, including the spring outward of plate edges, with a diameter of 3 feet. Four bolts retained fair holding power. The structure had sprung back 2 inches, and had recovered itself in the elastic earth. The middle upright of the backing was somewhat shattered. The outer plate was cracked a distance of 2 feet at the indent in the lines of the perforations.

"While the target was considered as not having sustained vital

injury, its weak construction, in particular as regards bolting, was apparent, and its condition unsuitable for the prosecution of the experiments with still heavier charges. The plating was therefore removed, the injured backing timber replaced, and the bracing strengthened by a second series of support.

"As plating, eleven ⅞-inch sheets, which having been manufactured for the sides of an armored vessel, possessed a slight crown, were secured to the backing, using fourteen 1.5-inch bolts of wrought iron. The plates were likewise somewhat weakened by old bolt-holes, though less than those of the previous target. The completed structure, however, though still deficient in strength, represented more nearly the conditions sought for.

"A charge of 100 pounds of dynamite, suspended as in all previous cases of contact so that its weight assisted the bearing pressure, and with outside ignition—85 grains of fulminate in two primers—was exploded against the target with the following results:

"Depth of indent, 2½ inches; diameter, 2 feet. The edges of the plates at the ends were sprung forward about 2 inches, stripping the beveled bolt-heads through the outer plate. The backing structure had sprung back about 2 inches, and had recovered itself. None of the plates were cracked.

"In all of the previous experiments the bed logs and earth in front of the target were shattered and torn, a hole in the latter of a depth of perhaps 3 feet being made at the explosion of the charge of 100 pounds. It being apparent that the angle between the ship's side and the water surface offered conditions favorable to the development of more violent action of the gases, a structure representing the water surface—a 1-inch plate upon logs—was built up to the level of the center of the target, and a charge of 75 pounds was pressed firmly into the angle, and exploded, again using two primers containing 85 grains of fulminate.

"The effects of this charge were notably more decided than those of the preceding one of greater weight, the indent being deepened to 3½ inches, and the backing and bracing considerably racked and strained. The injuries, however, could not be considered as vital, and the target was left standing without repairs of any description for further experiments. The water-

surface structure was, of course, demolished, the iron plate being blown to fragments and the logs almost pulverized.

"The conclusion to be drawn from the results obtained is, that a modern armor-clad will not receive material injury by the explosion in superficial contact with iron over water plating of very large charges of dynamite."

Second, as regards the explosion of guncotton on horizontal plating:

"In constructing the target for this experiment, an endeavor was made to represent the strength of 2 inches of steel suitably supported.

"Three perforated wrought-iron plates, similar to those already described in the dynamite experiments, were joined firmly together, using eight 1-inch bolts. The three-fold plate thus formed was bolted to heavy timbers distant from each other about 4½ feet. Two 1-inch bolts were placed at each end, passing nearly through the timber. To eliminate, as far as might be, the effects of the perforations, sheets of ¼-inch iron were inserted on each side of the middle plate, while a third was placed upon the target to receive the charge. There was thus a total strength (nearly) of 3¾ inches of iron.

"Twenty-five pounds of wet guncotton were exploded upon this target, using for ignition (placed above) 20 ounces of dry cotton with 85 grains of fulminate.

"A hole, 7 by 8 inches, about one-half the area of the base of the charge, was blown through all plates with the effects of the explosion reaching a depth of about 18 inches in the rather friable earth beneath. The bend of the plates extended to the timbers, without starting the bolts, with a depth of about 7½ inches."

Recently the Ordnance Department of the army made the following experiments at Sandy Hook: A 12-inch steel shell, containing 78 pounds of emmensite, was suspended vertically with its point in contact with a horizontal 3-inch steel plate resting upon timbers about 2 feet apart on the ground. Sand-bags were piled around so as to enclose shell and plates. The detonation of this shell produced practically no effect upon the plate, but the sideways blast was very violent, throwing the sand-bags in all directions and to considerable distances.

A similar shell loaded with smokeless rifle powder, sus-

pended in the same way, and exploded by simple ignition, produced fully as much effect as the emmensite shell, and in neither case were the results, except as regards greater fragmentation of the shell itself, any greater than would have resulted from a black powder charge.

All of these examples lead to the same conclusion—that the effects of the detonation of moderate quantities of high explosives are very great as far as immediate surroundings are concerned, but are comparatively slight otherwise. In the cases of the infernal machines and of Capt. Folger's experiments, the high explosive charges were not confined in strong-walled shell, and, consequently, their energies were not expended in shattering such shell, and they did more damage to surrounding objects than would otherwise have been the case. The army test of 12-inch shell, first loaded with emmensite and detonated, and then loaded with powder and exploded by ignition, gave a more direct comparison than we have elsewhere, and this surely does not indicate any greatly increased destructive effect from the high explosive. The truth is, that people underestimate the violence of gunpowder shell explosions, and exaggerate the others.

What the effects produced by bursting a 13-inch forged steel shell with gunpowder are, may be judged from the following test made at the N. P. G. in May, 1895:

A closed triangular chamber 7½ feet high was made with three armor-plates as the sides, 18 inches, 18 inches and 12 inches thick respectively, and the two former weighing, with their backings, about 43 tons each. The two perpendicular sides of this triangle were 15 and 7½ feet long respectively, and the short side was formed by the 12-inch plate, which was securely backed and supported by heavy braces and struts from behind. The shell, loaded with 53 pounds of ordinary shell powder, was placed on its side on a 1½-inch plate about 4 feet square on the ground in the middle of the triangular space. The top of the enclosed space was covered by three 3-inch plates, each 10½ x 5 feet, placed side by side. On explosion, the shell burst into many pieces, sixty being recovered, amounting in weight to three-quarters of the total. One of the 43-ton sides of the chamber was moved bodily to the left, its outer end 8 feet and its inner end 3 feet; the other 43-ton side was moved

bodily one foot to the right; the three covering plates, which weighed 3 tons each, were thrown into the air, one landing 6 feet away on top of the adjoining butt, a second falling back outside, and the third falling back inside the space enclosed by the vertical armor-plates. The 1½-inch plate on which the shell rested was dished all over its surface, the greatest amount being 8 inches, and a piece 16 x 6 inches was sheared off its side. The heavy armor-plates were dented in several places by fragments of the shell, but otherwise uninjured. Considering the foregoing, I think we may fairly reach the same conclusions in regard to a large-caliber shell of ordinary capacity as in the case of the smaller shell, namely, that to be effective they must be made strong enough to get through the ship's side before they break up or are burst, and that if so made the charges of high explosive which they will contain, amounting to about the same weight as if of black powder, while breaking them into more pieces, will yet not have a sufficiently superior destructive effect, if any more so, to justify their use instead of shell loaded with black powder. If the shell breaks up on the plating, the detonation of its charge will be comparatively harmless, and, since a very large part of the area of modern battleships is covered with armor, this renders it desirable to make the walls of the 13-inch, our largest shell, so thick as to reduce its capacity to about 50 pounds of powder. This shell will go through 6-inch armor whole and, consequently, will be effective over almost the entire area of an opposing ship, but to load it with guncotton and a detonator would, in my opinion, not render it sufficiently more destructive than when loaded with black powder to justify incurring the additional risk to our own ships. The premature detonation of such a shell loaded with guncotton would undoubtedly disable the gun and almost certainly put a turret out of action, while the premature explosion of such a shell loaded with powder would have no injurious effects whatever. On the other hand, the only gain from the use of the guncotton bursting charge would be a somewhat greater number of pieces from the burst shell with a correspondingly increased probability of killing and wounding men exposed to its pieces. Whether loaded with powder or with guncotton, the shell would be harmless if it struck armor which it could not penetrate, and in case it did

penetrate the plating and burst inside the ship, the structural damage done by the high explosive would not be greater but rather less than that done by the powder.

It should be clearly understood that this is a question of expediency only; undoubtedly we can load our ordinary shell with guncotton and fire them with reasonable safety from our ordinary guns with the moderate velocities, and we don't do it merely because we don't think it desirable, not because we are waiting for some one to invent a way to do it. The trouble is that the disadvantages outweigh the advantages. The only advantage is greater fragmentation of the shell when it bursts, while, on the other side, are the disadvantages of greater cost, greater danger in using, and greater necessity for care to prevent accident or deterioration. The powder shell, after being loaded and fused, is perfectly safe and needs no looking after, but if you use guncotton you must be always on the lookout to see that the main charge is kept wet, and that the detonator is kept perfectly dry; then you must, for safety and ease of examination, keep your dry primers and your fulminate separate, so that each shell must be prepared just before firing; then the detonating fuse, with the delay-action arrangements necessary to prevent harmless explosion before penetration, is not only expensive, but much more liable not to function properly than is the simple percussion fuse of the powder shell. Finally, as regards danger, while we say it is reasonably safe to fire moderate charges of wet guncotton with properly arranged detonators, yet we must not forget that *any* shell may explode prematurely. Now, if the powder shell explodes in the gun, it does nothing more than perhaps scratch the bore, but if the guncotton shell detonates in the gun, it will probably destroy it Suppose, for example, an obstruction in the bore, which checks the shell up a little in its motion, this is exactly as if it struck the enemy's side and, therefore; if the detonator functions properly you at once have a premature detonation.

It seems evident that to justify incurring these disadvantages there must be shown a far greater gain in efficiency than I have been able to find exists, and, therefore, I am forced to conclude that the use of detonative charges of high explosives in ordinary shell is undesirable. For armor-piercing shell, which cannot be burst by powder, it is of course desirable to use an explosive that will break them up after their passage through

armor, but the capacity of such shell is so small that any delay-action detonator would leave no room for explosive, and so we must be content not to detonate, but simply ignite their charges by the ordinary fuse.

One more word about the safety of firing ordinary shell loaded with high explosives, and I am done with them. The springs and air-cushions and other devices for lessening the shock of firing on the explosive charge are utterly useless; indeed, they are worse than useless, for in many cases they would really increase the danger of premature explosion; the only precaution to take is not to have too long a column of the explosive; it is its own inertia, setting it back and compressing its rear layers, that is the danger, and the greater the weight borne on the rear layer the more likely it is to explode. Cushioning can do no good for the reason that the maximum pressure does not come onto the explosive until the shell has moved several calibers, before which time any practicable spring would have been compressed to its limit, so that just when the cushioning is most needed it is not there.

All the foregoing must be understood as applying to shell of ordinary capacity. We have yet to consider the advantages and disadvantages of using high explosives in special shell of very large capacity.

In a paper which I had the honor of reading before the War College some time since, on the subject of probable future developments of ordnance, after stating an opinion similar to the foregoing, I said in conclusion: "In other words, the only possibility with the high-explosive shell is to use as great a weight of explosive as can be safely thrown, to provide means for its detonation on impact, and to trust to the effects of such a detonation outside the ship." "How destructive these effects would be we do not know, but for my own part I believe they are greatly overestimated."

In a succeeding paper I shall describe some experiments which have been made on this subject, and endeavor to show that the use of high-explosive shell, even with the largest admissible bursting charges, is not desirable.

II.

In my preceding paper I endeavored to show that the use of a high explosive as the bursting charge of shell of ordinary

dimensions and capacity was undesirable, as not affording sufficiently greater destructive power to justify the greater risk incurred in its use. My conclusions were as follows:

(1) The effect of the explosion of a shell of ordinary dimensions and capacity outside a ship, by reason of its being unable to penetrate the plating which it strikes, is practically nil, whether it be loaded with powder or with a high explosive.

(2) Consequently it is very desirable to make shell sufficiently strong, which means thick-walled, to penetrate the plating of an opposing vessel without breaking, so as to burst inside her.

(3) Such thick-walled shell, when loaded with a high explosive, are more dangerous to handle and fire, and are very little, if any, more destructive in their effects than if loaded with gunpowder.

(4) Consequently, if anything is to be really gained by the use of high explosive shell, it must be by means of shell of very large capacity, or what have been aptly called "torpedo shell."

In this paper, then, I shall consider the popular theory that overwhelmingly destructive effects will be produced by the detonation of very large charges of high explosive against, or even near, a ship.

Much less is known of the field of serious damage which would result from the detonation of 300 or more pounds of guncotton than of that which smaller charges would cause. Experiments have shown that the effects of say 50 pounds of guncotton are extremely local, but perhaps the explosion of 500 pounds would be a very different matter, and it was on account of this lack of knowledge founded upon actual experience that the Bureau of Ordnance undertook the experiments with the Gathmann shell, which I shall now refer to.

But first let us examine the results of a great accidental explosion of which we have detailed information, and see how far-reaching its effects were. I refer to the famous Stowmarket explosion, which took place at the guncotton works of that name in England, on August 11, 1871.

On this occasion, 13½ tons of dry guncotton exploded, and as there had been a few years before an explosion of about 51 tons of black powder at Erith, the official report compares the results of the two explosions and points out the comparatively local effect of the guncotton.

The 13½ tons of guncotton which exploded at Stowmarket was stored in three small wooden magazines, side by side, 14 feet apart, and only separated from each other by brick walls. The noise of the explosion was heard 30 miles and the shock was felt 7 miles. Some windows were broken 4 miles away, and some window-frames and sashes up to about one mile away. Slight material damage was done at distances from one-quarter to three-quarters of a mile away, but, as a general rule, not beyond 450 to 500 yards. Wooden cottages of very light construction were seriously injured at a distance of from 300 to 400 yards from the seat of the explosion, and the brick factory buildings, at distances varying from 20 to 50 yards, were practically destroyed. In the fall of the factory buildings a number of people were killed and wounded, the total of casualties being 24 killed and 50 injured. There is, however, no record of death or injury to any person from the effect of concussion merely. It is stated in the official report on the explosion, that a man standing on the railway, 76 yards from the magazines which exploded, was blown over a hedge and stripped of all his clothes, but was uninjured. The crater of this explosion was 35 yards by 22 yards long, 9 to 10 feet deep. The cause of the explosion was almost conclusively proved to be the presence of acid in the guncotton, probably due to careless manufacture, though perhaps to malice. A secondary explosion of several hundredweight of dry guncotton took place while an attempt was being made to remove it from the ruins of a store-house in which it had been kept and which had been overthrown and set on fire by the first or main explosion. This produced a crater 7⅔ x 8 yards by 3 to 4 feet deep. Terrible as the results of this tremendous explosion appear, I cannot doubt that its effects upon such a structure as that of a modern steel ship would have been insignificant except at very close range. The forces which will overthrow light wooden or brick walls are insignificant compared with those which a steel ship will withstand. Of course, people in the open, or at open ports, and near enough to be struck by the rush of heated gases produced by an explosion, will be either burned to death or killed by the dynamic effect of the blow, but one must be very close to be in danger of this. Far-reaching destruction can only result, if at all, from the concussive effect of the air-wave which is propa-

gated from the seat of the explosion. Take, for instance, the detonation of 300 pounds of guncotton, which would occupy a spherical space of about one foot radius. When the gases, rushing outward in all directions, occupy a space of 20 feet radius, they will have expanded 8000 times, and if confined in such a space, would exert a pressure of only one atmosphere. Of course, the dynamic energy of the gases at 20 feet from the center of such an explosion is still great, and they would do more damage than the mere static pressure indicates, but the illustration shows how rapidly they lose their force as they expand. But independent of and prior to any direct effect of the expanding gases, the enormous pressure caused by their almost instantaneous production gives an impulse to the air, something like a sound-wave, which transmits the initial pressure in all directions. It is this wave of intense compressure, followed by expansion, which breaks windows, etc., even miles away from an explosion. Unfortunately, but little is really known in regard to the intensity of the effects of this air-wave. Within the rather limited field of the direct action of the gases of explosion, it is not possible to draw any exact line between their mechanical effects and those of the air-wave, and although we know that all really distant effects are due to the air-wave, almost nothing is known of how serious such effects are as regards human life.

Granting that at 10 feet or even a less distance from the explosion of 300 pounds of guncotton, the direct action of the gases would be withstood by the side of a steel cruiser, what would be the effect upon people behind that side? If the ports were open, the inrush of heated gases might be sufficient at so short a distance to destroy life; but supposing that there were no opening in the side; could the shock injure people behind it? It is almost inconceivable to me that injury should be done to people completely sheltered by rigid plating as long as such plating is not broken through or down, but I have found that it is not an uncommon opinion that the shock, or concussive effect of an explosion, can be transmitted through an unyielding obstacle and injure people behind it. This was one of the objections urged a few years ago to the Holland submarine boat project. It was said that the explosion of its own torpedo, even at such a distance as not to injure its hull, would yet disable its

occupants. Experiments made at the torpedo station, however, completely disproved this. A Lay torpedo shell, 28 feet long by 3 feet diameter, built of about ⅛-inch iron plating and containing animals, was suspended 15 feet below the surface, and mines, consisting of 81 pounds of dry guncotton, also submerged 15 feet, were detonated at *various* distances varying from 305 feet to 80 feet. The last explosion, at 80 feet, bent in the plating of the boat at several places, but in no case were the animals injured, and it was apparent that a further increase in the severity of the shock would simply result in breaking through the plating and so killing the animals by drowning.

From our experiences up to this point, then, we could safely conclude that to do serious damage to a ship, or to her crew, by the detonation of a high explosive in the air outside the ship's plating, it would be necessary to use a sufficiently large weight of the explosive to actually blow in the plating, and that such moderate weights of guncotton as had been tried, up to 100 pounds, had shown but trifling effects of this sort. It remained to be determined, then, by actual test, how serious would be the effects of the largest charges of guncotton which would be likely to be used in shell, and when Mr. Louis Gathmann, of Chicago, presented to the Department his very ingenious plan for firing extraordinarily large charges of guncotton from powder guns, it was decided to give his ideas a test and at the same time to find out whether or not such shell would have the destructive effect generally supposed.

Mr. Gathmann's plan was to construct his shell with a very strong head and very thin walls; the rotating band to be at the bourrelet, or junction of head and body of shell; the outside diameter of body to be considerably less than the diameter of bore of gun, so that the powder gases would surround and press upon the shell; and the base of the shell to be closed only by a gas-tight plunger or piston. By this construction, the shell being filled with wet guncotton, the powder pressure would be transmitted by the movable base-plug and the wet guncotton to the inner walls of the shell, exactly balancing the powder pressure on the outside of the shell walls, and, consequently, theoretically, the shell walls could be made as thin as one pleased without risk of their being either burst or collapsed. Thus, instead of having to put 90 per cent of the total weight of the

projectile into the steel body in order to have it strong enough to stand being fired from a gun with high velocity, Mr. Gathmann proposed to put only 60 per cent or less, and to have 40 per cent in the form of explosive.

There were just two weak points in the foregoing theory: 1. The powder pressure in a large gun is by no means uniform throughout the chamber; on the contrary, from the moment the charge is ignited the gases are rushing to and fro, producing excesses of pressure now here and now there, and, consequently, a very thin-walled shell might easily be broken up in the gun, notwithstanding the arrangement for producing equal pressures inside and outside its walls. 2. The entire propelling pressure on the base of the shell was transmitted through the wet guncotton, and, consequently, if wet guncotton could be exploded by such a pressure as was used in the gun, the Gathmann shell would be a failure.

The first difficulty was overcome by making the shell of very strong material—nickel-steel forgings—and their successful operation, as far as this point was concerned, was demonstrated by firing two of them filled with water.

As to the second point, as we knew wet guncotton would stand almost any slowly-applied pressure, and as the charge of the shell was to be of saturated guncotton put in copper cases, and with all interstices filled with water so as to completely fill the shell cavity, we felt reasonably sure that the danger of premature explosion would not be great. As the sequel proved, however, this source of danger was underestimated.

The gun, improvised for the test of the Gathmann shell, was a 13-inch tube forging, bored, rifled and chambered like a 12-inch gun, and having a 12-inch breech mechanism fitted in a heavy steel forging screwed over its rear end. It was calculated to stand an internal pressure of about 10 tons per square inch within its elastic limit, and would undoubtedly have stood very much more without bursting.

The shell contained from 307 to 320 pounds of guncotton each, and were fitted with detonating primers consisting of a fulminate igniter, half a pound of dry guncotton, and about three pounds of wet guncotton contained in a steel primer case with walls one-half inch thick and screwed into the nose of the

shell. In the first attempts to explode one of these shells the necessity for close contact between the primer and the main charge was well illustrated. In the primer case a strong diaphragm had been fitted separating the one-half pound of dry from the three pounds of slightly wet guncotton, and the one-half-inch steel walls of the primer case separated the entire detonating arrangement from the main charge of the shell. The result of the first attempt to explode one of the shells by electricity, using 35 grains of fulminate in the center of the one-half pound of dry guncotton was as follows: There was a very mild explosion, scarcely audible at the bomb-proof near by; the head of the shell was ruptured, a number of pieces being found in the vicinity; the forward copper case containing wet guncotton was torn and its contents scattered all about; and the main body of the shell containing the remaining four copper cases of wet guncotton was pushed some ten or twelve feet from its original position. Evidently the one-half pound dry primer had detonated, but had merely set on fire the three pounds of wet guncotton, separated from it by the diaphragm, and the combined force had nearly ruptured the front end of the shell without exploding or setting on fire the main charge of wet guncotton.

A second attempt was then made with a shell having the diaphragm separating the wet and dry parts of the detonating primer removed. The results were practically the same as before, the head of shell ruptured and the main body, with its charge, thrown a few feet to the rear, sliding along the ground.

To prove that these results were entirely due to the separation of detonator and main charge by the walls of the primer case, and not to any lack of strength or sensitiveness in the guncotton, one of the copper cases containing 71 pounds of wet guncotton, and taken out of the shell which had just failed to function, was exploded on a live oak block 14 x 16 x 15 inches long, by means of a one-pound dry primer and a service igniter of 35 grains of fulminate placed on top of it. The result was perfect detonation, and the complete disappearance of the oak block, not a recognizable portion of it being found. The results other than this, however, were almost nil.

The next experiment made was with a shell having the walls of its primer case perforated by ten holes, each about 1½ inches in diameter, so as to allow a more direct action of the primer

upon the main charge of wet guncotton. The dry guncotton in the primer was also increased to 10 ounces instead of 8 as before, and the primer case was fitted with a cover of tin sheeting to keep the water from entering from the shell body and drowning the dry primer. The igniter, as before, was 35 grains of fulminate of mercury, exploded by electricity from a bomb-proof. The shell was placed on its side on the beach, between two screens constructed as follows: Three uprights 8 x 12 inches were let into the ground about 3 feet each and supported from the rear by braces 10 feet long and 6 inches square. To these uprights were secured, each by six 1½-inch bolts, steel plates about 13 feet long by 7 feet wide and ⅝ of an inch thick. These screens were 50 feet apart, facing each other, and the shell was 15 feet from one and 35 feet from the other. On firing there was complete detonation. A hole in the ground 14 x 9 feet and 1½ feet deep was the principal result. One small fragment of the shell had been driven through each of the screens, and other fragments had struck them, making only slight dents. The plates were not bent, displaced or injured in any other way. Only a few fragments of the shell itself were found and these were small, showing how completely it had been destroyed. A very slightly-built wooden latrine standing on the sea-wall, 93 feet from the shell, and with nothing interposing between them, was only injured by the explosion to the extent of having two or three of its boards displaced by being pulled off from the nails holding them to the framework.

The trifling effects of this detonation of a shell containing 320 pounds of guncotton was, I need hardly say, a complete surprise to most of those present. That a light screen, in no way approaching in strength the side of a steel cruiser, and only 15 feet away from the explosion, should be uninjured was rather a damper to the enthusiasm of people who prophesied the destruction of a ship by a single one of such shells. It was said, however, that even granting the experiment to show only extremely local effects from the explosion, yet these effects were tremendous upon objects in contact with the explosive, and as the idea was to explode the shell by impact against an enemy's ship, it by no means followed that such an explosion would be comparatively harmless. It was still claimed that no armor-plate, however strong and well backed, could withstand the explosion of such

a shell in actual contact with it. Accordingly it was determined to make one further experiment to test this point.

The plate used was the ballistic test-plate which had represented the Kearsarge's side armor, and was of nickel-steel, face-hardened, backed with 12-inch oak and two ½-inch skin plates, weighing 28 tons in all. It was 7½ feet high by 16 feet long, and of a thickness tapering from 16½ inches at top to 9½ inches at bottom. This plate was placed against an ordinary target structure, but not tied to it in any way, and other armor-plates were placed at right angles to each end of it to confine fragments. The shell, containing 307 pounds of wet guncotton and a primer of 8 ounces dry, 2 pounds nearly dry, and 35 grains fulminate, was suspended by ropes so that it lay horizontally against the plate and along its middle line. It also had a light wood blocking support. The detonation was perfect so far as could be judged by the character of the report and results, but only comparatively trifling damage was done. The surface of the plate was scarred and roughened as if it had been partly fused, for a length of about 5 feet and a width of 8 inches abreast the suspended position of the shell, and there was some very slight flaking from the surface near the old shot holes. A hole was made in the ground along the front of the plate about 2½ feet deep, and partly as a result of this, and partly, perhaps, by rebound from its supports, the plate was swung away from its original position, one end leaving the target structure about 2 feet. Two 1-inch steel plates on the ground below the projectile were broken up and their pieces driven into the ground and dispersed about the vicinity. The side of the shell itself next the plate was flattened out and burned into a ragged sheet 5 feet long by 8 inches wide, practically fitting into the fused portion of the plate, but detached and falling to the ground. The remainder of the shell was dispersed in very small fragments.

The armor-plates at the sides were practically unchanged in position, and the effect upon surrounding objects, such as a lot of oak blocking on the ground 40 or 50 feet away, was very much less than would have been that of the blast of a 12-inch or 13-inch gun fired with its muzzle at the point of explosion of the guncotton shell.

To observe the effect upon animal life, four chickens had been

placed in different positions. One on the ground behind the center of the plate and one foot from its backing. This chicken was entirely uninjured, and upon being released showed no effects of the explosion, thus proving conclusively that people behind an armor-plate need have no fear of high-explosive shell.

One on the ground directly in front of the center of the plate and 43 feet from it. This chicken was killed by a flying fragment, which, of course, indicates nothing of importance. Its feathers were not blown off, except where it was struck, and it appeared to have but that one injury.

A third chicken was placed in one corner of the cellulose compartment of a coffer-dam, practically in front of the plate and 50 feet from it. This coffer-dam, consisting of an armor-plate with a thin steel compartment for cellulose behind it, had been fired through and its back, which faced the explosion, had been torn wide open, so that the chicken, in one corner, had much the position which a man would have if he stood well outboard and close to the side of a ship's port. This chicken was entirely uninjured.

The fate of the fourth chicken is rather mysterious. It was placed in another coffer-dam similar to the one just mentioned, but much nearer the explosion, about 25 feet, and having no perforation in it, so that it could only be affected by concussion coming from above down into the compartment. This chicken was found to be dead, but with no external marks of injury, and what killed it is, as I have said, not at all certain. Possibly it was internally injured by the concussion from the air-wave propagated in all directions and reaching it from above, but more probably it was killed by being in contact with the very thin plating of the coffer-dam and being struck by that, which of course must have yielded somewhat.

This experiment would seem to completely dispose of the theory that a high-explosive shell of very large capacity will blow in the side of an armored vessel if exploded against it. But there is one more objection which has been raised to this conclusion. It is said that the motion of the projectile will greatly increase the effect of its explosion on striking. The idea is that the energy of the projectile will act, as it were, as a tamping to the explosive, the gases of which will tend to continue onward and so will act in that direction with greater force than if they came from a stationary explosive. This is un-

doubtedly true to a certain extent, but the increase in effect can be only trifling. Suppose, for example, that at the instant of explosion the projectile were advancing at the rate of 1500 f. s., then the gases of explosives would expand in the outward direction with 1500 f. s. greater velocity than they would to the rear; but what is 1500 f. s. more or less when we consider the velocity with which the gases rush from the explosive center under the influence of the pressure of hundreds of tons per square inch produced by a detonation. No, this tamping effect of its striking velocity can add nothing material to the force of a high-explosive shell. We can safely conclude that such a shell, even if of the largest practicable capacity, exploding against the armored side of a vessel would be practically harmless. We can also safely conclude that such a shell, exploding in the air, even very near to an unarmored vessel, would do no serious structural damage to her. In other words, the effective sphere of the torpedo shell is far more limited than is usually supposed; it is superior in its effect to an ordinary powder shell only if it explodes inside a ship or under water close to her side. We have then to decide whether the greater effects of the large capacity high-explosive shell within the above limits are sufficient to justify incurring the greater dangers of their use.

It must be remembered that in the very nature of things that which is dangerous to an enemy is dangerous to ourselves. The powder which propels our shell against the enemy may burst our own guns or explode in handling; the fuse which should act on impact with the opposing ship may act prematurely to our own destruction, etc. The best that we can do is to devise and apply safety devices to render our weapons innocuous until the moment when we wish them to act upon an enemy, but there is always the possibility of premature action with injury to ourselves instead of our opponents. The real question, then, as to the use of any weapon is, how do the chances of its damaging an enemy compare with the chances of its damaging us, and how would the results of its successful use compare with those of its accidental premature use? Take, for example, the use of the Whitehead torpedo on cruisers, in regard to which there is much difference of opinion; if the chance of an accidental explosion before firing is very small and the results of

such an explosion would not be very serious, and if, at the same time, a successful hit with the torpedo would put an enemy out of action and there is a fair chance of making such a hit, then the use of the torpedo is not only justified but demanded. But if, on the other hand, an accident of very possible occurrence may prematurely explode your torpedo, and if this explosion would put your own ship out of action, then the use of the torpedo would not be advisable. As regards the torpedo, I am strongly of opinion that the first statement of the case is correct; nothing but a direct blow upon the detonator could explode the torpedo, and the chance of this happening is almost infinitesimal. Moreover, even if it happened, and the torpedo were detonated while in its launching tube, I am satisfied that the damage done would be confined to the torpedo-room. The largest torpedo, the long 18-inch Whitehead, only carries 220 pounds of wet guncotton, and its explosion in a torpedo compartment of ordinary size ($16 \times 64 \times 8$ feet $= 8192$ cubic feet on Kearsarge and Kentucky), while it would of course kill every one in that compartment, would not seriously damage the ship nor, in my opinion, do any damage at all outside of the compartment. It would be much better to have the explosion take place above the water-line than below it, for it might tear a good-sized hole in the ship's side around an underwater tube, while if exploded when being used through an open port above water, the damage to the side would be of no importance, and, moreover, in the latter case there would be a free escape of the gases of explosion. On the other hand, the chance of hitting with your torpedo an enemy attempting to ram you would be very good, and the effect of hitting him would probably be to disable him by at least filling several of his compartments with water and perhaps sinking him.

The use of the above-water torpedo on unarmored ships is, then, in my opinion, very desirable, but when it comes to the use of torpedo shell, it seems to me that the best of the argument is on the other side. We have seen that the chance of the torpedo shell doing very great damage to an enemy, even if it hits him, is comparatively small. All battleships nowadays are well covered with armor against which such shell would be harmless, as they would explode outside it; only in case they struck where they could penetrate would they do great damage.

Moreover, the reduced velocity necessary for the safe firing of torpedo shell considerably reduces their chance of hitting at all. Can we afford to not only reduce the chance of hitting the target but also to greatly reduce the area of target against which a hit will count, for the sake of somewhat greater effects from a successful hit? If a successful hit meant destruction to the enemy, we might, but not otherwise, I think. Then, again, the premature explosion of the torpedo shell would do us the maximum harm that such a shell could do. The above-water torpedo, if exploded prematurely, explodes in the air in a large compartment containing nothing of vital importance, while if it hits it explodes against the underwater side of the enemy where it will do its maximum of damage. The high-explosive shell, on the other hand, if exploded prematurely, is just in the position with regard to our own ship that we hope it to reach in an enemy's ship before exploding; if successfully fired and exploded, it is more likely to burst harmlessly outside the enemy than to penetrate and burst within her. As to the actual chance of such a premature explosion of a torpedo shell, I still hold exactly the same opinion as when I said some time ago, in a paper read at the War College on "Probable Developments in Ordnance," that we could safely fire about 175 pounds of wet guncotton with a velocity of about 1600 f. s. from our present 12-inch gun. I did not mean that there would be absolute safety with such a shell, or as much safety as with a powder shell, because any shell may explode prematurely, and the premature explosion of the guncotton shell would be far more serious than that of the ordinary shell. I do mean, though, that the danger of firing torpedo shell is not too great, provided their use is demanded by other considerations. It is the fact that I do not believe their effectiveness is sufficiently greater than that of powder shell that causes me to conclude that we should not use them; it is not that I believe their use, in a proper way, impracticable. One must be satisfied with low pressure in the gun and, consequently, low velocity of the projectile, and one must not sacrifice safety to the desire to throw too large a weight of explosive. It was going too far which caused the failure of the Gathmann shell. If we had been satisfied to fire it with, say, 4 tons pressure in the chamber instead of 8, it would probably not have exploded prematurely. I don't advo-

cate, and never did, such an arrangement as the Gathmann shell. I believe if we use high explosive shell at all they should be like any other shell, only thinner-walled; but, nevertheless, the Gathmann shell was based upon a correct theory and would no doubt function properly in actual practice as long as the pressure on the wet guncotton was kept low enough. The premature explosion of the one shell that was fired was undoubtedly due, in my opinion, to the setting on fire, either by pressure alone, or by the powder gases getting into the shell body, of the wet guncotton charge. There was no detonation, only an explosion of low order. The rear end of the gun was broken into large pieces, and the rifling remained quite perfect everywhere, whereas a detonation would have smashed the lands quite flat in wake of the shell. The pressure gauges all registered 28 tons, and I am satisfied it was nothing but the excessive pressure produced by the combustion of 394 pounds of powder and 300 pounds of guncotton which burst the gun; the gases could not get out of the muzzle fast enough and so the pressure rose till the gun walls gave way. The effects of the explosion can be seen from the photographs, and it is very surprising to see how the guns and carriages mounted on one side of the gun which had burst escaped injury. Whether such an explosion would have burst a service 12-inch gun cannot be absolutely determined, but I am very strongly of the opinion that it would not have. The detonation of such a shell in the bore would have burst any gun, but with free escape for the gases at the muzzle it is not likely that the simple combustion of the guncotton would produce a sufficient pressure to actually burst a modern gun.

Finally, then, the matter stands thus:

(1) The high explosive shell, whether it contains an ounce or 300 pounds of explosive, must penetrate the side of a ship before bursting in order to do serious damage; however large its charge, it will burst harmlessly against armor.

(2) This makes it necessary to arm our battleships with high-power guns of large caliber, firing armor-piercing projectiles, as the only means of getting through the thick armor of opposing battleships and thus reaching their vital parts.

(3) We can fire thin-walled shell loaded with guncotton from these same high-power guns by considerably reducing the

velocity, but there is much more danger to ourselves with such shell than with powder shell; the chance of hitting with them, on account of their reduced velocity, is much less, and they would be effective only against that comparatively small and unimportant part of a modern battleship which is unprotected by armor.

(4) We can use guncotton, or some other high explosive, instead of powder in thick-walled common shell, such as will pass unbroken through the armor, but its use is more dangerous, and its effect but slightly, if at all, superior to that of powder under the same conditions.

Therefore, in the present state of my knowledge, I am forced to conclude that the advantages of using high explosives in shell are outweighed by the disadvantages, and that unless some new light is thrown upon the subject in the future, we should continue to use powder for bursting charges, and not high explosives.

NOTE.—All the foregoing is in reference to the use of high-explosive shell in naval warfare. Their employment with field and siege batteries on shore is advocated upon stronger grounds of reason, since, especially with the former, the objective generally counts upon more or less exposed bodies of men. There is no doubt that much greater fragmentation of the shell can be obtained from the detonation of a high-explosive charge than from the explosion of a gunpowder charge. There is greater danger to the user and there is more uncertainty of obtaining successful explosion with high-explosive than with gunpowder shell charges, but a well-placed shell, properly exploded, will certainly kill and wound more men in the former case than in the latter. Even here, however, the most exaggerated and false ideas appear to me to be prevalent as to the importance of the advantages gained. All that I have read in regard to the effects of the English lyddite shell in the Egyptian campaign and in the present war in South Africa, has tended to confirm my previous conclusions. Such observers as do not allow their imaginations free play to the end of producing sensational copy seem to have been greatly surprised at the lack of effect produced by what they had been led to believe were fearful weapons of destruction. In Egypt, the frightful slaughter of the Dervishes appears to have been wrought by the Maxim automatic guns, not by shell fire. In South Africa, numerous reports show that the Boers rather prefer lyddite shell to the ordinary kind, their principal objection to the former being that their explosion turns people and things in the near neighborhood yellow. And, finally, I have been told by an officer of our army that the dynamite field-guns used in the Philippines are rather a source of laughter than a dreaded weapon, the natives making a practice of standing up at their trenches and bowing

politely after each shot, as if to thank us for our consideration in using such harmless projectiles against them.

In the service of coast-defense guns, there is also an advantage to be derived from the use of high-explosive shell which does not exist in naval warfare. I refer to the torpedo-effect of such shell when exploded under water in close proximity to the hull of a hostile ship. In sea-fighting the flat trajectory is vitally necessary on account of uncertainty of range as well as for many other reasons; but from fixed shore batteries, even mortar-fire may prove effective; and with the latter, or even with ordinary guns at ranges too great to allow of effective fire from a ship, the angle of fall is sufficient to cause shell to enter the water and not to be deflected from its surface. If such shell carry large charges of a high explosive and are fitted with an effective delayed-action detonator, their radius of destructive action is considerably increased over what it would be if they were loaded with gunpowder, for if they explode sufficiently near the under-water body of a ship, they will rupture her bottom plating and either sink her, or at least disable her. The gunpowder shell, on the contrary, however large its charge, would, in my opinion, do no damage by its under-water explosion to the hull of a modern ship of any size unless it exploded so nearly in contact that the actual fragments of the shell were driven through the plating. It is principally because they wish to secure this torpedo-action for mortar shell that the Ordnance Department of the U. S. Army has been for years, and is still, experimenting with high explosives. As far as I am informed, their tests have not tended to encourage the prevalent ideas as to the greatly increased destructive effects produced by high-explosive shell. I have been told that a solid steel shot produced a much more destructive effect upon an armor-plate than did a shell of equal caliber filled with explosive gelatine, both being fired at an angle of some 30 degrees with the normal to the plate, thus confirming the conclusion I reached from the firing of a 6-inch guncotton shell against an armor-plate at the N. P. G. some years ago.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE DEFENSES OF MANILA BAY.

By Lieutenant John M. Ellicott, U. S. Navy.

Only a few years before our war with Spain, that country was threatened with another war whose theater would have been chiefly her colonial possessions in the Pacific. War with Germany over the Caroline Islands was so imminent that military plans for the defense of the Philippines were carefully elaborated, and modern high-powered rifled guns were shipped to Manila and emplaced, while ammunition in vast quantities was received and stored. Thus, in the fall of 1897, there stood before the city of Manila four 9½-inch breech-loading rifles, nine 8½-inch muzzle-loading rifled mortars, four 5½-inch converted breech-loading rifles, and fifteen 6.3-inch muzzle-loading bronze rifled guns of old design, all carefully emplaced behind heavy earthworks, fully equipped and superabundantly supplied with ammunition. All batteries were connected by telephone, and plane tables were arranged at the extremities of measured bases, to give accurate ranges. Drills were carried on continually and with enthusiasm.

The old city of Manila lies upon the right bank of the Pasig's mouth, surrounded by a picturesque medieval wall, fifty feet thick and twenty feet high, and by a deep moat. The wall along the bay front is practically straight, with a bastion at each end and one in the center. Five of the 6.3-inch muzzle-loading bronze rifles stood in the north bastion and eight in the south, while in the center were five muzzle-loading rifled mortars. Many other very old muzzle-loading bronze guns lined this wall, but they were recognized, even by the Spaniards, as obsolete. All the artillery on the walls antedated the German scare. The modern formidable guns then emplaced were located in front of the wall

and moat, in earthworks well screened by shrubbery and sod. One 9½-inch rifle was placed under the north bastion and one under the south, while the four 5½-inch converted B. L. R.'s were placed near the center bastion, and four 8½-inch mortars on the flank of the south wall. The two remaining 9½-inch rifles were placed some distance to the southward, on the water front, in the suburb of Ermita.

A new battery, to hold six 15-centimeter Ordoñez rifled guns was built on Sangley Point for the protection of the naval arsenal at Cavite. This was a casemated earthwork of entirely modern character. The Cavite arsenal had also three 6.3-inch Armstrong M. L. R.'s mounted in a stone redoubt, and on Fort San Felipe, a medieval fortress adjacent.

The old fort of San Antonio Abad, which had figured so much in the war history of Manila, was too antiquated for modern artillery emplacement.

Such were the defenses of Manila when the new war cloud gathered in the winter of 1897-8. Much more had been planned, and the incentive of renewed danger brought the plans out for revision and execution. One of the large Spanish ocean liners sent to the Philippines, the Isla de Mindanao, was loaded with guns and munitions of war and started from Spain. Believing, perhaps, that these guns would reach them in time for emplacement at Cavite, the military authorities at Manila sent four of the 15-centimeter rifles belonging to Fort Sangley, about the first week in March, to Isla Grande in Subig Bay. In Manila, however, they added two modern 15-centimeter B. L. R. siege guns to the battery of 5½-inch B. L. R.'s under the west wall, and placed two 12-centimeter B. L. R. siege guns in the circular redoubt on the south mole of the Pasig River mouth, where there were already two 6.3-inch M. L. bronze rifles.

At the same time, the emplacement of batteries for the defense of the entrance of the bay was entrusted to the Navy. This entrance, though very wide, is divided into two channels by a large island called Corregidor.

In twenty-four days the following batteries were ready to defend these channels:

Covering Boca Chica: On the north shore of Corregidor Island, three 8-inch M. L. Armstrong rifles; at Punta Gorda, north side, three 18-cm. Palliser M. L. R.'s, and at Punta Lassisi, farther in the bay, two 16-cm. Hontoria B. L. R's.

Covering Boca Grande: On Caballo Island, three 6-inch Armstrong B. L. R.'s; on El Fraile Rock, three 12-centimeter B. L. R.'s, and at Punta Restinga, three 16-cm. Palliser M. L. R.'s.*

They also reinforced Fort Sangley by one 14-centimeter B. L. R., a few hundred yards up the beach, and were preparing to mount a second beside it when the American squadron arrived. The gun here mounted was taken from the cruiser Ulloa, she being so far dismantled for repairs that they moored her head and stern for battle and retained only her starboard battery.

At all of these batteries were built bomb-proofs in the ground, with covered galleries or trenches for approach, while in sheltered spots near at hand were roomy bamboo quarters for the guns' crews. An abundance of ammunition was provided, and the guns were manned chiefly by sailors from such vessels as were *hors de combat* because repairing at Cavite Arsenal.

A line of mines was laid northwestward from San Nicholas shoal, in Manila Bay, and others were laid in Boca Grande, but firing arrangements for the latter seemed not to have been installed when Commodore Dewey's squadron arrived.

At Subig Bay some hulks were sunk to block the southeast channel, and mines were being laid in the northwest channel when our ships arrived, but the four 15-centimeter guns, through inexcusable and inexplicable procrastination, remained prostrate on Isla Grande. Had they been mounted there or at Fort Sangley at the end of April, 1898, the Battle of Manila Bay might have been quite another story.

The merchant steamer Isla de Mindanao arrived in Manila the last week in April, too late to unload all her munitions of war before the arrival of the United States squadron, and her fate is now a matter of history.

Such, then, were the land defenses of Manila Bay which confronted Commodore Dewey when his squadron stole in silence and darkness towards the entrance at midnight, April 30, 1898. The Spaniards had guarded their work well. U. S. Consul Williams, who remained in Manila till one week before that date and who accompanied the American squadron back, could only

*The Caballo Island guns were taken from the dismantled cruiser Velasco. This battery therefore received the name of that cruiser and was manned from her crew. One of the Fraile guns was taken from the Ulloa and two from the gunboat Leyo. This battery was named Leyo, and manned from that gunboat.

learn that numerous new batteries were being erected at the entrance to the bay and that the channels were being mined. No knowledge of the relative strength of the defenses of the two channels could guide the American commander's choice. The wider channel, Boca Grande, was the one selected. The squadron thus passed under the muzzles of nine rifled cannon, some of them modern breech-loaders, and through a mined channel. In Boca Chica it would have encountered eight rifles, two of them breech-loading, and no mines, but there were also in this channel a small Spanish gunboat, the Arayat or Leyte, and a picket launch.

Allowing four large guns as a cruiser's broadside, giving double weight to batteries on shore over those afloat, and counting the mines efficient, it might reasonably be claimed that a contest with the defenses of Boca Grande in daylight would have been about an even fight.

By referring to the diagram showing the zones of gun fire at the mouth of the bay, it will be seen that the United States squadron unwittingly took a course which placed it longest under fire and led it through the zone of heaviest concentration. At the speed the squadron moved, eight knots per hour, and granting most liberal times for the service of the Spanish guns, the latter could have hurled about five tons of projectiles against the American vessels before they were out of range. Nevertheless, the route was well chosen. We all know the actual story: the squadron half way through before detected; then a geyser of flame from the McCulloch's overheated smokestack; a single rocket from Corregidor; a signal flare on El Fraile rock, five impotent shrieking shells from it and Punta Restinga; innocuous mines; and the daring squadron safe within the bay!

Had the Spaniards provided for every contingency, a score of idle gun vessels and armed launches could have patrolled the Manila "bocas" at night, so that even a canoe could scarcely have approached undetected. As it was, the absolute silence and the perfect screening of lights on the American vessels made them undetectable at a few hundred yards distance. The moon in its first quarter was setting behind clouds. A single guiding light, shut in on three sides, was necessarily displayed at the stern of each vessel. The course steered prevented these from being seen from the Restinga and Caballo batteries until the

squadron had passed nearly out of their sectors of gun fire. Then, too late, they gave each battery in succession a target: Restinga fired, but Caballo probably thought the enemy already out of range. The flare up from the McCulloch's smokestack was but a brief accident which the Spaniards could not seize to advantage. One feature of the passage was the close approach of the squadron to El Fraile rock. That the Spaniards would have a battery on this isolated and tiny island was not expected, so, as it made an excellent point of departure for a course up the bay, it was approached within five hundred yards, and its battery promptly opened fire. A few shells in return convinced the gunners that their position was perilously exposed and untenable at such short range, and they desisted.

In the face of all evidence, the existence of mines at the entrance to the bay can scarcely be doubted. A chart was captured at Cavite next morning with lines of torpedoes marked on it in Boca Chica and off San Nicholas Shoal, and with marginal memoranda about the spacing and number of mines. In the articles of capitulation signed bv the Governor of Corregidor, it was stated that mines existed in Boca Grande. The testimony of nearly every Spanish officer interviewed by the writer after the fall of Manila was to the same effect. If these mines were contact mines, they had become innocuous from barnacles and seaweed or badly adjusted moorings; if they were electro-controlled, the firing devices had not been installed or were defective.

Having run the gauntlet of nine rifled guns and a line of mines unharmed, our squadron stood up the bay in a direction a little north of Manila, thus safely passing around the mines, if they existed, off San Nicholas Shoal; and in the morning, as it reconnoitered the roads off the city and then stood down toward the discovered Spanish fleet at Cavite, it came under the muzzles of thirty-six rifled guns, twelve of them breech-loaders, and thirteen of larger caliber than any in the American ships. Situated as these guns were, however, they could not fire upon the enemy without drawing a return fire not only upon themselves but upon their city: their homes, their places of business, their wives and children. Nearly nine tons of projectiles could have been hurled at the passing enemy while within range of those Manila guns, but they were paralyzed by their false emplacement. The three batteries of 9½-inch guns, however, being

least disadvantageously emplaced, opened, and, through bad marksmanship, kept up an impotent fire throughout the action.

The batteries at Cavite added four hundred and sixty-six pounds of metal to the broadside of the Spanish fleet throughout the first engagement. The duel of the Baltimore with these batteries was a feature of the second engagement. Such a hail of exploding shells plowed into their entrenchments that they resembled volcanic eruptions. Though several times silenced, they as often renewed the fight until their final surrender.

When the work at Cavite was finished, the Olympia steamed alone to Manila, followed soon after by the Baltimore and the Raleigh. These three ships, once more under the muzzles of Manila's thirty-six shotted guns, coolly anchored in the harbor, the bands of the Olympia and Baltimore playing their evening concerts as usual, while Commodore Dewey sent word to the Governor-General that if a single shot was fired at the American ships he would lay the city in ashes.

The isolated batteries at the mouth of the bay were, by orders from Manila, surrendered to the Raleigh and Baltimore on the evening of the 3rd of May. Their breech-plugs were delivered on board the Raleigh. Each battery was visited by landing parties from the American ships, the guns disabled and the ammunition thrown into the sea. At a later period, when it was found that the Philippine insurgents were endeavoring to remove some of the guns, they were all again visited and thrown into the sea.

The guns on Sangley Point were destroyed with gun-cotton. The ones at Manila fell into the hands of the United States Army when Manila was taken, and still remain monuments to the folly of those who emplaced them in such tactically embarrassing positions.

Defenses of Manila Bay.

About March 10. A council of war at Manila decides to hasten erection of four 15-cm. Ordoñez guns at Subig, block one channel with sunken hulks and mine the other and place the fleet there.

About March 15. The captain of the Leyo submitted a plan for defence of Manila and Cavite, fortifying the mouths of the bay with a line of batteries on points conveniently located and another second line of more moral and material strength, com-

posed of torpedoes protected by two batteries at their extremity, situated between Punta Amos, in the Province of Bataan, and the shoals of San Nicholas. Artillery available:

	Ranges.
6 Muzzle-loading Armstrong rifles, 180 lbs.	3600 meters.
7 16-cm. conv. M. L. Palliser M. L. 1	5600 "
12 16-cm. conv. M. L. Palliser M. L. 2	5000 "
3 18-cm. conv. M. L. Palliser	4400 "
2 16-cm. B. L. Hontoria, 1879	5000 "
4 12-cm. B. L. Hontoria, 1883	10500 "

Last four on board Ulloa.

Sites visited by a committee on the Bulusan.

March 29. Fraile, Caballo and Restinga chosen; Carabao rejected.

Captain and crew of Velasco land Caballo battery and named it Velasco.

Captain and crew of Leyo land Le Fraile battery and named it Leyo.

120 workmen from Cavite Arsenal and 30 laborers from Corregidor employed on batteries April 1, Leyte, Bulusan and Hercules used.

Fraile battery had one 12-cm. Hont. B. L. R., 1883, from the Ulloa and two 12-cm. Hont. B. L. R., 1879, from the Leyo.

Caballo battery had three Armstrong 16-cm. B. L. R. from the Velasco.

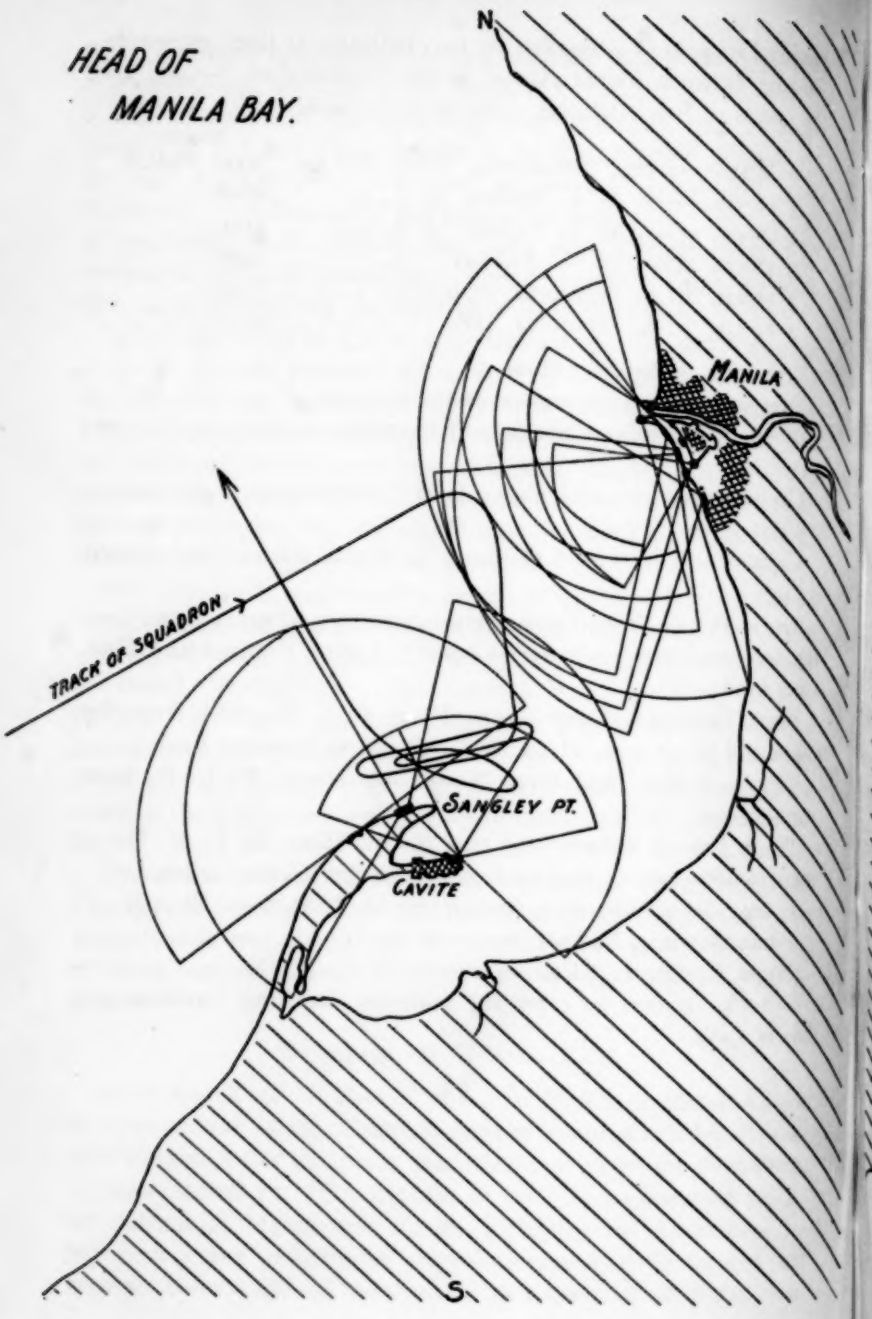
Punta Lassisi battery had two 16-cm. Hont. B. L. R. No. 3 modern 1879, which had been stored in the (Cavite) arsenal.

Corregidor (Talisaz): 3 Armstrong M. L. R. 6-in. 180-pdr.

Punta Gorda: 3 Palliser 18-cm. M. L. R.

Punta Restinga: 3 Palliser 16-cm. M. L. R., No. 1.

It took 22 days to erect the batteries, working Sundays and Saints' days.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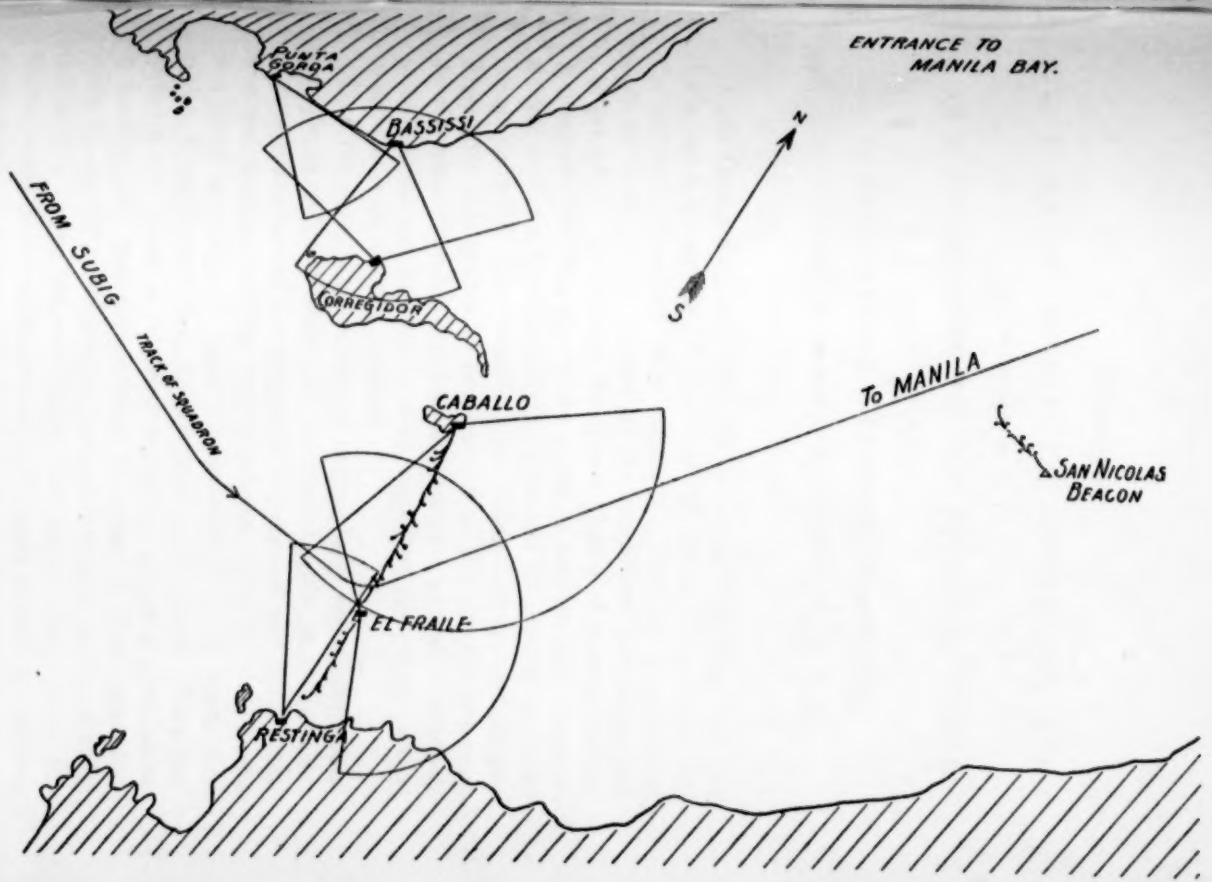
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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

AN INTRODUCTION TO THE STUDY OF NAVAL TACTICS.

By RENÉ DE CARTOUT, Lt.-Comdr. French Navy.

Translated from the *Revue Maritime* by Prof. Jules Leroux.

Naval Tactics may be defined as the art of disposing fleets for battle; but it is essential to give to all the terms of that definition the extensive meanings they admit of. The art of disposing fleets for battle is not limited to the formations and evolutions that precede or accompany the divers phases of a naval action; it comprises, besides, the whole series of studies and measures tending to the disposition of the elements of combat in every one of the units that constitute the fleets. These preliminary dispositions will permit to be obtained at the decisive moment, the best possible utilization of all the weapons, and will contribute to the final success as much or even more than the purely tactical combinations of the last moment.

Thus the part of the tactician begins long before the actual struggle; in reality it takes place in time of peace, at the moment of the preparations of the designs of the men-of-war, their armament and their assembling into squadrons. It is his duty in the first place, to adopt or reject improvements of all kinds that modern science offers daily for weapons of naval war. However perfect a new weapon, however ingenious seems a mechanism, he must control their employment in regard to their utilization within the special conditions of their performance on board ship; that is, in a heavy sea, and under the enemy's fire. Next, his efforts should be directed towards judiciously gathering together all the means of action at his disposal, to creating types of vessels

adapted for the purpose he has in view, to disposing them in homogeneous groups, of which every element completes one another, and lends each other mutual aid.

This important task, the true preparation of all tactics, is not that of the supreme command alone; each captain contributes to it, not only when called upon to superintend the final details of a new vessel, but even when in a ship in commission, his duty is to adjust and utilize the existing arrangements, to make the most of their qualities, to point out and, if necessary, to correct as far as possible their defects. During the first period of his career the officer studies the theory and practical part of all the branches that compose nautical science, branches so various and so complete in themselves that in order to make himself efficient he must confine himself specially to one of them.

But from the moment he takes command he ceases to be a gunner, a torpedoer, or a fusileer, and becomes exclusively a specialist of that complex weapon called a man-of-war. Leaving henceforth with others the care of seeing to the proper performance of the various machinery, he rises to the conception of their simultaneous and judicious action during the combat; that is, of their tactical employment. Each disposition he takes with this object in view, specially during the period of the first armament, exercises a direct influence upon the future results of the struggle during which the collective power of the vessel will be made apparent.

To qualify himself for this work of preparation, a commander should not be contented with the experience acquired in the inferior grades. In most cases the vessel to be disposed for combat has but a remote resemblance to those upon which he has already served. None of the latter will be useful to him as a term of comparison. The "ideal" type, which in his mind conforms with the actual necessities of naval warfare should alone inspire the resolutions he takes, and the appreciations he sets forth. It is therefore necessary for him to possess comprehensive ideas, a theory or, if you prefer it, a doctrine, setting off to his satisfaction a clear conception of what should constitute squadrons and warships.

It is this doctrine that we propose to study in the following pages, without seeking to place it above the inestimable teachings of experience, and with the sole ambition of formulating a few

of the general principles upon which, owing to the rapid and radical transformations of the material, rest actually the construction and the constitution of warships.

FIRST PART.

NAVAL WARFARE.

General Notions of War.—The logical basis of every conception of a military order consists, for the officer, in a sound appreciation of the true character and importance of the mission he is intrusted with.

War is not only an unfortunate necessity of our epoch, a remnant of the ancient barbarity we must put up with until nations have acquired the wisdom of coming to an agreement in order to avoid it; such a notion is incomplete, and does not suffice to give to him who is in command the serene and implacable sense of the duty he fulfils. The officer must convince himself that war is something else than an accidental and unfortunate necessity, that it is in reality one of the laws, and perhaps the highest, that presides over the development of society. It is the decisive and inductable phase of the struggle for life legitimately practiced nowadays between nations, after being practiced between individuals, families, clans, and provinces.

In the unceasing and after all profitable conflict of ideas and interests, resort to violence, as a last and supreme argument, can never be done away with as long as there shall exist distinct nationalities, for no one of them has the right to dispossess itself of the inheritance of its intellectual traditions, and acquired wealth, to renounce without being forced to it, its proper existence. The final unification of races and classes towards which tends the unconscious effort of humanity, is compatible only with a higher degree of civilization and ethics from which it is yet very far off.

Universal peace will reign some day, but only through the final conquest and exclusive predominance of the race proving itself the most noble, most intelligent and most powerful. The object of war is to affirm and secure, in view of that far-off selection, the development of national life, through resistance to rival nationalities, or through their assimilation.

Peculiar Characteristics of Modern Wars.—Although war is the

fecund instrument that has brought together in the course of ages, and soldered one by one all the elements that constitute the Fatherland, its true mission has been perhaps often misunderstood. It is more apparent nowadays, because progress of the human mind by making wars more rare, has at the same time contributed to make them more murderous. To long armed rivalry of former times have succeeded short and decisive encounters, which diplomacy tries to ward off, knowing full well that they are unavoidable, and in which are manifestly at stake no longer the vain satisfaction of personal ambitions or rancors, but collective interests and often even the very existence of a nation. It can be easily understood that this supreme circumstance demands the concourse of every energy. Thus, social life come to a stand still, commerce suspended, agriculture itself neglected, the whole nation standing fully armed on the frontier, claiming and absorbing all the resources of the country in its deadly work, form the peculiar and striking characteristics of modern wars.

Preparations for war consist, in a general way, in drilling the greatest possible number of valid men, in accumulating the immense supplies they will require in their achievements, and in carefully studying the various plans of attack and defense. There is still another point we must not lose sight of, and this is, that it is not sufficient for a nation in order to establish her supremacy to be the stronger and more intelligent; she must above all be the more noble, in other words, the more moral, and more imbued with her duties. The most terrible arms are powerless in the hands of men deprived of this internal force against which nothing can prevail.

The first and most efficacious preparation for war is the raising of the moral level of a nation. Modern war should not be only the supreme manifestation of intelligence and force, it should besides assume the character of an exalted affirmation of morality.

Of the Rôle and Importance of Maritime Frontiers.—Frontiers being the natural or conventional limits of a country, may in some way be considered as the organs of the exterior life of the country and its relations with other nations. In times of peace they serve to regulate the exchange of different products of the soil, or of industry, and in times of war they constitute the inviolate bulwarks of the Fatherland.

The rôle of maritime frontiers is from this double point of view very different from that of land frontiers. By means of the latter, indeed, one country is in direct contact with its neighbors on the Continent. It is in a certain measure their tributary in a commercial point of view, since its commerce can only be established with them or through their intermediary. It strives to overflow them with the surplus of its productions of all kinds, and in its turn it has to bear the incessant invasion of the merchandise, ideas, and even idioms of its rivals. This unceasing work of assimilation, stimulated by the continuous development of ways of communications, brings on as a consequence, swift and acute state of vital competition between two nations separated by a common frontier. If war breaks out, the attack or defense of this frontier is the initial and dominating fact of the hostilities, of which the seat must necessarily be the territory of one of the two nations. The struggle thus begun may have as a result a modification of the frontier, in consequence of the annexation by the conqueror of the neighboring provinces, or even the crushing and complete assimilation of the vanquished. War between two bordering nations is therefore the most threatening, the most terrible, and the one to be prepared against with the utmost care.

The maritime frontiers through which one country communicates with all other nations plays quite a different part. The sea is the highway open to all, leading to all ports, and it follows that maritime commerce, assuming an importance far superior to that carried on by land, is to the country the real fecund source of greatness and wealth. In a military point of view, the violation of maritime frontiers is in reality an act of a secondary order, presupposing that the ocean fleets constituting the first line of defense have been previously rendered powerless. This violation, besides, constitutes an exclusively maritime operation, limited to the coasts, but can, however, be followed by an invasion of territory through the landing of troops.

War between two nations that do not possess common frontiers begins necessarily by sea, and continues with attacks against the seacoasts. The same may take place in case of two contiguous nations having the same sea outlets, as in the case of France and Italy, for instance. Both countries leaning on the land side against the Alpine mass, have their respective coasts advancing

to form the western basin of the Mediterranean. Their commercial relations are more easily carried on by sea than through the mountain passes, hence a conflict of interests which logically would lead them to contend, in the first place, for the supremacy of that common sea.

On the contrary, war between two countries with common land frontiers but separate sea coasts must of necessity be a continental war. It would, however, be unwise in such case to neglect the importance of the maritime frontiers. As already seen, each one of the two countries involved absorbs, for the struggle the totality of its land resources. But these resources are limited, and it may be presumed that the two confronting armed powers, backed respectively by a line of fortified places and entrenched camps, will not succeed at once in terminating the struggle in a decisive battle. It will, therefore, become a matter of great importance to both nations to be able to appeal to the neutral powers, and to receive through their seacoasts the supplies of all kinds, they will need. The navy then will be charged with the double duty of keeping open the access to the coasts and of depriving the adversary by blockade of all communication with the neutrals.

It is proper to call here attention to the particularly favorable situation of France in a geographical point of view. By means of the Mediterranean and Algeria she rules Africa, and through the Canal of Suez, which is her work, she extends her influence to the extreme East. Through her Atlantic coasts she looks upon the New World, and the fleets that spread out from her two maritime frontiers may be compared to two arms always extended towards the unlimited commercial wealth of the globe.

Through her land frontiers, stretching from the south to the north of Europe, she can and ought to exercise a legitimate influence upon the Continent. But let us not forget that maritime commerce alone can furnish her with the material means of exercising that influence. It is from an energetic and wise colonial policy that she must derive the means she is in need of to support the necessary claims of her continental policy.

Object of Maritime War.—The preceding considerations suffice to set off the important rôle of the navy in war, and to determine the object it ought in all circumstances to strive to attain. Whether carried on against a neighboring nation or a country

separated by the sea, whether its object be the immediate defense of the coasts of the mother country or the extension and safety of her interests in distant lands, the naval action of a great people purposes always to conquer the supremacy of the seas in determined parts of the globe; that is, to maintain in said parts freedom of communications for herself, and to shut off those of the adversary. It is with the view of satisfying this double object that war fleets must be built and disposed.

Limited Field of Action of Modern Fleets.—Let us first set forth that modern fleets are powerless to realize this object in all parts of the world, to choose indifferently as their fields of operations, the vicinity of the coasts, the European waters, or the distant seas, in imitation of the sailing fleets of the last century. The latter, finding their motive power (wind) everywhere, and being otherwise enabled to procure in every country the supply of food and water necessary for their crews, possessed the unquestionable tactical advantage of an almost unlimited radius of action.

The characteristics of modern fleets are, on the contrary, to join with a great fighting power a very limited radius of action. On one hand the organs of propulsion, powerful engines and large boilers, occupy the greater space of the vessel. On the other hand, the weight of the guns, the armors, and all kinds of machinery constitute the greater portion of the exponent of lading. It is impossible to increase the coal capacity—in other words the vessel's radius of action—without interfering with her speed or fighting power. On the other hand, fuel being properly considered contraband of war, cannot be furnished by neutrals.

Defenses of the Coasts.—The organization of the defense of the coasts is not of paramount importance to a nation whose fleets possess an undisputed superiority upon those of her possible rivals. Great Britain, for instance, can with reason consider her men-of-war as the true bulwarks of her coasts. On the contrary, when a part of the littoral is situated in the immediate vicinity, and subject to the constant menace of a superior maritime power, all kinds of preparation for its defense become a necessity of prime importance. Such is the case of our Channel coast.

The principal object of the defense of the coasts is to oppose a landing, and the squadron should lend all its force in that

undertaking. The secondary objects are resisting all the enemy's attempts, such as a temporary occupation of a point of the coast, destruction of semaphores, blockades, bombardments, and the laying of contribution on seaports. In any case, the defense has to face an enemy afloat, and as we have already remarked, is an exclusively naval operation. The troops convoyed by the assailing fleet are inactive; they become offensive only after landing; that is, after an ineffectual attempt to defend the coast; it then becomes a question of defending the invaded territory, which task and responsibility devolve upon the army.

The operations of the navy are always limited to the defense of the coast-line so called. This defense is secured principally by batteries and forts constructed on the shores, in the vicinities of the most accessible points. Those works, having to fight men-of-war, should be armed principally with guns similar to theirs, and capable particularly of piercing their hulls. The methods of firing should even resemble to a degree those employed on board ship against a moving object. The land fortresses are therefore real ships on land, and their sea faces can truly be compared to a broadside of a vessel. The comparison becomes scrupulously true, in speaking of the lower (tier of guns) or armor-piercing batteries, which are often protected by turrets similar to those of a man-of-war. The upper batteries and mortar batteries can also be easily manned by seaman gunners.

Looking theoretically at an action between a fighting ship and a coast battery, one must conclude that the advantage will always remain with the latter. The battery, in fact, can indefinitely increase the thickness of its parapets or steel facings with the use of the disappearing gun-carriage and smokeless powder; it may be made invisible from the sea, and besides possesses a limitless supply of ammunition. The man-of-war, on the contrary, is always in sight. Its protection is limited, and it can only fire a certain number of shots. It follows, therefore, from this statement that the defense of the coast can be secured by forts alone, on the condition that they are completed by sufficient obstructions in the passes, by means of lines of torpedoes and stockades. However, as it would be impossible to build works upon all vulnerable points, their action must be extended and completed by a defense fleet whose units become in turn veritable floating fortresses, endowed with the quality that is lacking on land, motion.

This defense fleet always operating in sight of land from which it can always renew its supplies, needs only a limited radius of action. It can comprise divers types of vessels, monitors, rams, coast-guards, all intended to carry heavy batteries, and capable under certain circumstances of delivering a blow with the ram. It combines its operations with the torpedo-boats, the latter acting in preference by night and surprise, and seeking in daytime protection under the forts or the defense vessels.

Finally, moving columns can be employed to repel shore landings by hostile boats or light-draft vessels.

The elements of this organization so dissimilar in types should combine their action, and obey one sole impulse, which can only be a naval one. We think it useless to expand further upon its working, having only desired to point out the place the defense vessels of the fleet should occupy in it.

Fleet Operations.—The organization of the defense of the coasts can only be the prologue of the naval action of a great power whose territories, subjects, and even flag are scattered or engaged all over the globe. To abandon these interests, to renounce protecting the commercial highways that are the exterior radiating lines of national life, would be equivalent, even in the case of a purely continental war, to a first and irreparable defeat.

It would be vain to object that in such case the fate of the country will be decided on the land frontier, and that naval action, however brilliant, would be without influence upon the issue of the struggle. We think this a very questionable opinion. We have already pointed out the necessity for every belligerent nation to secure not only the safety of, but still more, the access to, their coasts. The possibility of obtaining supplies by sea and preventing the adversary from doing the same may decide the final success.

France particularly has a paramount interest in securing as soon as possible the supremacy of the seas in proximity with her coasts. In regard to Germany, France should be able to close against that power the passages of the Channel and the North sea.

On the other hand, France occupies two shores of the Western Mediterranean Basin, and can no more permit interruption of communications between Alger and Marseille than she can allow the enemy to cut off one of her provinces from the rest of her territory.

Beyond doubt the primary object to pursue in time of war, is to prevent invasion by a hostile army, but there is no reason to think that this cannot be done by sea. In a case where the land frontier is formed by a natural obstacle like the Alpine range, for instance, an adversary having command of the sea may prefer to use the latter as an open and easy passage for his armies. It is, therefore, of the highest importance to the security of the territory to prevent the enemy from obtaining the mastery in the adjacent seas.

That result cannot be obtained by a convenient extension of the coast defenses. Torpedo-boats, as we will show further on, are powerless to realize the object we have in view, and the same would be true of all vessels of high speed, but of a military value inferior to the fighting power of the enemy's battleships. Can we expect the coast-defense monitors to oppose the passage of the adversary? To do that they should have the speed and radius of action they are lacking, they should be joined by cruisers and scouts indispensable to prepare and complete their action—realize, in one word, the deep seas' squadron.

Thus, whichever way we look at it, appears the necessity of maintaining in the North and in the South, two fleets representing the highest expression of the nation's naval power, and whose mission should be to wrest from the squadrons of our possible adversaries the supremacy of the seas adjacent to the country. Those squadrons will play in regard to the coast frontiers the same part the army will play on the land frontier, with this difference, however, that whilst the latter is necessarily massed on the frontier at the opening of hostilities, the naval forces face the enemy in front and apart from the latter.

We have not to examine here how operations will begin between hostile fleets. Both adversaries being alike convinced of the necessity of obtaining the supremacy of the seas, may seek each other from the breaking out of hostilities. It would perhaps be a good idea to force the enemy to accept combat by undertaking at once one of those secondary operations which logically should take place only after the encounter between the two squadrons. Let us simply state that the encounter is bound to take place, and will exercise on the results of a war, even on the Continent, a considerable and perhaps decisive influence.

It is hardly necessary to mention that in case of a war with a

naval power, squadrons will play the principal parts. It would be a mistake, for example, to suppose that England's naval power could be seriously shaken by a commercial warfare, *i. e.*, a war undertaken against her merchant marine. The English squadrons, having free possession of our adjacent waters, would blockade our ports and prevent our cruisers from going to sea. If a few of them succeeded in forcing the blockade, it would not be very long before they would be captured by the enemy's cruisers, after a more or less lengthy career, for want of coal. Fleet operations, with a view of keeping open access to our ports, would still be in this case the necessary prologue to privateering.

It will be noticed that up to this we have reserved the name of squadrons to the powerful fleet intended to contend in adjacent seas against European rivals. Naval warfare in distant climes will demand fleets, which to obtain a greater radius of action, must necessarily possess a lesser fighting capacity.

Operations against an Enemy's Coasts.—An attack against coasts can only be an episode of fleet contests; in principle it should follow them, becoming only possible after victory. If we consider in particular the principal object one can possibly have in an attack against an enemy's coast, that is the landing of an army corps, we maintain that this can only take place when protected by a squadron that commands the seas. The necessity of protecting the convoy and material would indeed place such a squadron at a very great disadvantage, if it must besides contend against intact forces of about equal strength. That squadron must also keep off detached cruisers, fight coast-guard vessels, as well as mobile defenses, and if need be destroy works constructed at the points selected for the landing. All these operations, just as in the case of the defense of the coasts, lead to an exclusively general naval action, for the troops brought up can only fall into line after they have landed.

Blockades of navy-yards and commercial ports can only be undertaken by a squadron after the destruction of the adversary. Owing to the restricted field of action of modern fleets it is necessary in such a case to establish in the vicinity of the blockaded place a secondary base of operations, where the assailant can renew his supplies, one vessel after another, and which is connected with the principal base by transports entirely secure against attacks.

The forcing of passes is an operation which a squadron will sometimes find advantageous to undertake if it can afterwards turn around, and attack the enemy's works from the rear. In principle, however, we cannot recommend the attack of a fortified dockyard from the front. A squadron operating alone could not, without risking great losses, attack forts and force an entrance to a first class dockyard, where it could not find a lodging and had no means of occupying. Whatever the injuries inflicted upon the adversary in that action, it would expose itself to the loss of several of its fighting units, and consequently jeopardize the supremacy gained upon the adversary at a great cost. It is only in case of the place being invested landwise by a corps of occupation that it could establish a concerted attack from the sea.

The bombardment of unprotected cities is not to be comprised among the operations that can be taken against an enemy's coast. The squadron, however, will no doubt demand from a commercial city, after sufficient delay, the money, the coal and the provisions it may stand in need of. But to appear suddenly before an open port, to burn and destroy it, would have no importance on the final results, and would be contrary to the higher principles we have advocated at the beginning of this work. It is not usual to fire upon an unarmed mob; firing ceases the moment the adversary strikes his colors, and with more reasons the persons and properties of non-combatants should be respected, except in unavoidable cases. Resistance alone calls for and justifies the use of force.

War on Commerce.—The foregoing conclusions are in part applicable to war on commerce. Operations against the enemy's commerce are certainly among the most potent in striking at its naval power. They complete the actions of the fleet by realizing upon every sea the object of naval warfare, which consists in obstructing everywhere the enemy's communications. By violating this implied interdiction in going to sea under the cover and protection of their national flag, merchantships share in a certain measure in the action of belligerents. They cannot therefore be respected under the same plea as private property of non-combatants.

It must, however, be well understood that the object of war on commerce is capture and not destruction of prizes. It is only

through force of certain circumstances when the captured ship becomes a menace or a danger to the captor, that the latter is justified in sinking the prize after, of course, previously taking off the entire crew. This obligation prevents light vessels and especially torpedo-vessels from entering upon commerce-destroying warfare, as having no means of boarding, or putting a prize-crew on board the captured vessel, they could only destroy them and coolly assist in the drowning of its crew. Commerce destroyers should possess heavy tonnage, a great radius of action, and superior speed. Their primary object is to prevent the maritime communications of the adversary.

Resumé.—The rapid *exposé* of the divers requirements of naval warfare just given, sets off the importance—a preponderant one—of properly called fleet operations. These alone by giving the supremacy of the sea. insure the defense of the coasts of the country and make possible attacks on the enemy's coasts, and war on his commerce. Now, as before, naval battles between battleships will decide alone the fate of maritime powers. That truth has not been altered by the radical changes that have taken place in the capabilities of the man-of-war, which being made independent, so to say, of the caprices of the elements, carries within itself the organs of its motion, and all the factors of its power.

SECOND PART.

THE MAN-OF-WAR.

Definition.—The man-of-war, the instrument of naval warfare, we say it again, must be built and fitted to enable it to realize the double object it has in view, namely, maintain free communications by sea for itself, and obstruct those of the enemy. Its mission is to act on the high seas, where it must be able to maintain itself, and sail in perfect safety. We will, therefore, not call by that name craft which, whatever their sizes and armaments, are obliged through stress of weather to seek refuge in port or slow down sooner than merchantmen of the same tonnage. This faculty of keeping the seas, which we will call navigability, is the essential and primary quality we will require from the constructor before thinking of any armaments.

We have seen, on the other hand, that the object of naval warfare is to conquer the supremacy of the sea, by either destroy-

ing men-of-war of the enemy or capturing his merchant vessels; it is only exceptionally that its action is directed against the coasts. Though the vessel's guns may be sometimes turned against the latter, the general disposition of its armament must be made in view of an encounter with men-of-war. The man-of-war should thus, it seems to us, be defined in a general way, a deep-sea vessel fitted to combat an enemy afloat.

Nautical Power and Fighting Power.—This definition comprises two parts that correspond to two terms constituting the man-of-war, the vessel itself and the armament, the float and the fortress. The first is endowed with the quality that permits it to move from one place to another, and the second possesses the required military efficiency to combat there. The nautical qualities, navigability, radius of action, speed, turning power, concern not only navigation; they have besides a considerable importance from a tactical point of view. They contribute largely to the efficiency of the fighting part of the vessel, and for this reason it seems to us proper to designate them by the general expression, "Nautical Power," in opposition to "Fighting Power," which comprises the generality of the defensive and offensive dispositions of the ship. It is essential not to mix up these two terms of the power of the man-of-war. We may at once set off the capital difference that distinguishes them from the tactical point of view, by enouncing the following rules, the evidence of which needs no explanation: 1st. A squadron's nautical power is exactly equal to that of the one of its units that has the least. On the contrary, its fighting capacity is the sum total of the fighting capacities of all the vessels composing it. It is perfectly evident that an assembly of vessels possessing different speeds can only move together with the speed of the slowest among them, whilst any ship having an armament and a protection adds to the offensive and defensive power of the whole; 2d. The nautical power of a vessel of a determined tonnage can only be increased at the expense of its fighting power and *vice versa*. Each one corresponds in fact to a weight completing the available fraction of the load exponent.

Before drawing any conclusion from those axioms, it is proper to examine briefly in the logical order of their importance each of the elements that constitute the opposite capabilities of the man-of-war.

Navigability.—The first of all, navigability, comprises several factors, the most important of which is, without contradiction, stability. We must demand that the man-of-way be "uncapsizable," not only from the action of wind or wave, but even—and this is essential—in case of a leak in one of its water-tight compartments. Otherwise compartment divisions instead of proving a security would constitute a danger to the ship. The stability of forms, which is the one we have in view, may be limited to a certain degree, owing to the necessity of obtaining the necessary stability of platform for the efficiency of fire of the guns. It is the constructor's part to establish under his own responsibility the proper compensation between those two terms of the stability and to fix the metacentric height, which joined with the special shape of the vessel gives it in any case the complete security it needs. On our part, we should then renounce in the course of the armament all military installation which would give an increase of weight to the superstructures, and the effect of which would be to reduce the radius of the metacenter.

It is not enough to secure the stability of the vessels; it must besides be made proof against the action of the seas. It is wrong to suppose that all the upper works may be made use of for fighting purpose, beginning at the theoretical plan of the waterline. It is important, in the first place, for the vessel to be enabled to keep up its fighting speed in moderate weather, not, of course, without a certain loss, but without any serious damage resulting or any great inconvenience in the firing of the guns. This essential capability of the man-of-war must be required not only in its solidity but also in its forms forward that are exposed to the action of the waves. This capability, for instance, must never be sacrificed in order to obtain by means of lowered forms the secondary advantage of a depressed fire for the bow-guns.

On the sides, the height of the waves, and the inclination caused by the rolling, render still further part of the upper works useless from a fighting point of view. The line which remains always above water, taking into account these two factors, the freeboard is the true termination of the hull. The part of the hull comprised between the waterline and the freeboard is not below water, but it cannot either be considered as being completely above the water. All the installations pro-

jecting out would very often be exposed to the blows of the waves, and would produce seas and sprays troublesome to the firing of the guns. This effect would be still greater in case of that part of hull having a "tumbling home" form. We must then demand before everything, from the constructor, that the plan of the hull up to the freeboard be even and straight.

Finally, the ship should be habitable (have good living quarters), and the crew find in all parts of the vessel, where they must stand, the necessary breathing air. The ventilation of the compartments—above all, those where the temperature is very high—must be abundant, not only under the ordinary conditions of sailing, but even while in action. It is inadmissible that the closing of hatches and doors of watertight compartments should expose the personnel to the danger of being asphyxiated. Let us add that in no case should the simple entrance of fresh air be thought sufficient, but that means must be provided for the evacuation of foul air; finally, to make habitability complete, there should be an upper deck where the men could at least take a few steps in the open air.

Radius of Action.—It is intentionally that we have placed radius of action immediately after navigability. If the latter is the preeminent quality of all deep-sea vessels, we may consider radius of action as the "prime determinante" of the man-of-war. By it the vessel is classified at once in one of the fleets that we judge necessary to the national defense, in the defense fleet, in the squadron, or in division in distant waters.

The radius of action is generally defined by the greater distance the ship can sail with its own means, reducing itself in consequence to economic speed, but in a military point of view, it is preferable to compare between themselves the distances possible at high speed. We will therefore define radius of action as the distance that can be always covered at fighting speed, and we will see further on what is understood by the latter expression.

We have already remarked, and as this study progresses it will be shown still more, that the radius of action can only be increased at the expense of all the other qualities of the ship. It becomes necessary, then, from the very first, to determine the minimum of speed that the vessel must have to perform the duty for which it is intended. It is the part of the tactician alone, that is, of the commander, to determine these first data that the constructor must not reduce under any pretext or circumstances.

The radius of action depends upon the quantity of coal that can be stowed in the ship's bunkers. This quantity should not include the coal for the divers auxiliary apparatus in use for daily life on board ship, or for the working of its interior organs. This fuel, that may be designated as coal for ordinary use, should be regarded as part of the ship's provisions. These supplies of food, fresh water, coal for ordinary purpose, should, like the radius of action, be determined for the constructor according to types corresponding to the fleets enumerated above. They necessitate the reprovisioning of the vessel at the end of a given period, which should be the more extended as the radius of action is itself greater, but these supplies should never be confounded with the propulsion coal which is only consumed in the displacement of the vessel. It may be of interest to remark here that any inopportune displacement of a man-of-war will decrease in part its tactical value by thus reducing the radius of action immediately realizable. We will say a few words, when treating of ordnance further on, about the ammunition supply, which affects only the fighting power of the vessel.

Speed.—Among all the elements of nautical power, speed is unquestionably the one that most directly contributes to the military action of the vessel; it must not, however, be comprised among the factors of the purely military or fighting power, to which it is never more than a useful auxiliary. The vessel possessing superiority of speed can always come up with or get away from its adversary. It is then in that position which can be compared with that of a vessel in former times having the advantage of wind. But, as in former times, this advantage is only really efficacious when at the same time the vessel possesses a superior armament to that of the adversary. When manifestly inferior in strength, it can only use speed to escape.

The speed that can thus contribute to the military action of a man-of-war has little in common with that obtained during trials with forced draft and under peculiar circumstances. The vessel will never again attempt to obtain that speed, for it might be the cause of mishaps that must be prevented by all means. The tactical speed, otherwise called fighting speed, is the one that can be indefinitely kept up with natural draft, without exhausting the personnel or the machinery, the crew being at general quarters. The last condition implies the possibility of pass-

ing the coal from the bunkers to the fire-rooms without interfering with the service of the guns or the passage-ways. The speed, or to speak more exactly, the fighting space, corresponds to a definite capacity of the engines, and a given number of revolutions of the screws. That is the one the vessel will commonly adopt in all war circumstances, reserving of course the power of increasing its speed in case of need.

Outside of parts frequented by the enemy, the man-of-war will often find it to its advantage to adopt the economic speed, which will allow it to obtain the maximum radius of action. There exists besides, an evident correlation between radius of action and speed. The two elements complete each other in giving the vessel all its nautical power, which becomes thus truly characterized by what may be called " radiating speed."

Turning Power.—To finish the enumeration of the various factors of the nautical power, there remains to say a few words touching the turning quality of the man-of-war. When the latter had but one screw, the diameter of its turning circle, in fact, described astern a circular zone, where the enemy found himself in a favorable position from the point of view of close attack with the ram or torpedo. The warship has less interest in limiting its gyrating circle since it possesses at least two screws permitting it to maneuver with more facility. It may, however, gain a marked advantage from the possibility of turning without modifying the speed of the engines. The constructor will therefore endeavor to give it this advantage, bearing in mind at the same time that the heeling caused by the turning maneuver must not interfere with the firing of the guns. It should be demanded also that the workings of all the mechanical agencies of gyration, helms, servo-motors, and command-wheels (*roues de commande*), should offer the same guarantees required in weapons of war, and which we will enumerate further on. We might say the same in regard to the motive-engines as well as the vital organs of the vessel which, in its ensemble, is in reality a gigantic weapon that the captain wields by means of the propellers and the helm.

Offensive and defensive Weapons.—The fighting power of the vessel is composed of two distinctive parts but inseparable the one from the other: the offensive power and the defensive. The first comprises the arms intended to act against the adversary,

and the second the arrangements of all kinds that allow of their working under the fire of the enemy.

The qualities required in a weapon of war are the following: In the first place, the weapon must be capable of being handled with perfect safety. It is essential that the crew should know that except in case of downright carelessness they have nothing to fear from the forces they put in action. Then the arm must be simple, that is, its mechanism must be worked in an elementary manner. The use of modern arms requires, no doubt, a special knowledge, principally in the mounting and regulating of the apparatus, but the arm must not be at the mercy of an indispensable man, the only one capable of handling it, and who might be wanting at the moment of combat. It is important, in the second place, that these mechanisms should be strong. Whatever their complication, they must be as much as possible proof against injury due to neglect or clumsiness. It is necessary that one should depend absolutely on the proper working of an arm at the very moment of using it. Finally, it must be efficient, in other words, capable of doing the greatest injury to the enemy. The last condition is evidently the most important, but it can only be attained after the other three. However terrible the effects produced by an arm, its adoption should be rejected if there should be any appearance of danger in its handling, if complicated or unreliable. In a word, we want an arm that is at the same time safe, simple, strong, and efficient.

To these qualities, which are general, should be added another, special to arms employed on board a vessel; their working and efficiency should be as free as possible from the motion of the ship. The offensive weapons of a man-of-war are of three kinds: the gun, the ram, and the torpedo. We lay aside small arms, such as rifles, swords, and revolvers, which although very useful, can hardly be considered as part of the armament of a vessel. This armament, intended to fight the enemy afloat, has two objects in view: sink the vessel by attacking the hull below water, or cripple it by acting against its essential organs and personnel, through the destruction of its upper works.

Inverted, the defense proposes to secure on one hand the floatability of the vessel, and on the other the protection of its various machinery and its personnel. These two terms of the fighting power of the ship complete each other. It is not expe-

dient to seek only in a bold and sudden offensive, the means of avoiding the blows of the adversary. At sea, where there is no natural obstacle, no rolling ground, it can be affirmed, specially in view of the recent advance in ordnance, that the best guarantee of an efficient offensive resides in a serious protection.

The Ordnance.—The gun is preeminently the arm of the battleship. Naval battles have always been and are still fought with the gun. The ram and the torpedo appear only as an episode, for the one of the two squadrons having the greater speed can keep a safe distance from their reach. The gun, on the contrary, is the arm of all distances, and suffices to produce the two effects we demand from the offensive weapons; that is, sink the adversary and put him hors de combat.

Its part is to pierce and destroy, and with this double object it uses in principle two kinds of projectiles, armor-piercing shells and high-explosive shells. Both act by impact, for the constant variations of distances between combatants do not permit the use of fuse firing except in special cases, as, for example, when using shrapnel against light craft at a calculated distance. Let us remark that it is sought by loading the armor-piercing projectile with a small bursting charge to produce a certain destructive effect after perforation; conversely, it is sought to obtain the bursting of the shell only after its passage through the hull of the vessel. In both cases we thus come nearer the model projectile, that is of that one capable of producing successively and completely the two results.

The obstacles against which the gun has to contend, if we refer to the enemy afloat, may be divided in three categories. The first comprises the parts of the vessel—for instance, turrets and water-line—that have the maximum protection and carry the heavier armor. Against those obstacles the heavier gun must be used, that is, the one which possesses the greater ballistic power. The ballistic power, which consists in velocity rather than in weight of projectile, is not necessarily in proportion to the caliber and weight of the gun. The power must be sought by using in the manufacture of the piece the most resisting and lighter metal. True, in the present state of metallurgic knowledge, the higher ordnance has necessarily a considerable weight, and the number of the guns on board is limited. They require in their use complex hydraulic or electric apparatus, whose work-

ing is slow. Besides, their ammunition supply cannot be considerable.

The firing of the heavy guns is necessarily less frequent and their ammunitions should not be wasted in the combat. It would in the first place, be bad tactics to fire them against obstacles of the second category comprising the parts of the vessel of medium resistance or protected only with a thin armor. Against these, moderate caliber guns will be more efficient. Their rapid fire will permit to throw against them a heavier mass of metal than a big gun could do in the same space of time. Finally, those parts of the vessel that are not protected, the thin plates of the superstructures, and the hulls of light vessels will be pierced or destroyed by the rapid fire of the light guns, which will, besides, act against the exposed crew.

The dividing of the ordnance in three groups, heavy, moderate, and light guns, is thus commanded by the very nature of the obstacles opposed to them, but it must be observed that the rôle of the heavy gun is always predominant. Its blows may be decisive, if the enemy is struck at the water-line, and they are always efficient whatever the part of the ship. There will be some advantage now and then in firing on the upper works with explosible shells of heavy caliber, which will work great destruction. The arrangements in regard to the number and position of the heavy guns constitute consequently the most important factor of the offensive power. Their number being limited by the necessity of displaying in a parallel line the other elements of the ship's power, they must be given the maximum utilization by providing for them an arc of train as considerable as possible. Theoretically speaking, the vessel might mount but one single heavy gun, the number of the fighting units being then increased to a desired proportion. But such an arrangement would constitute a poor use of the appropriation money and, on the other hand, it would not be possible to place this single piece in a position that would command the whole horizon. We are then reduced to the necessity of providing the vessel with at least two heavy guns placed in the axis, one forward, one aft, and having on each side of the median line the most considerable train possible. Those are the two places really fit for heavy guns, and if it is proposed to increase to four the number of these guns, on board large battleships, these two places will be the most desirable for them, two in one turret.

The above arrangement of the heavy guns presents, nevertheless, two objections: the first that an unlucky shot might disable two guns at the same time, but the realized economy of weight permits to give to these guns thus united the maximum protection, and as a consequence to minimize as much as possible this objection. In the second place, the bow pieces and the stern pieces, in crossing their fires, create on each side of the vessel a triangular zone that their fire cannot reach.

The lozenge-shaped disposition of the four heavy guns, that is, one forward, one aft, and one on each side, does not present any of those objections, and theoretically allows firing three pieces at the same time in each of the four principal directions, but this advantage is purely illusory, for the firing in the axis of the guns placed in the center and abeam can only be done by means of a tumbling home or defective form of the upperworks, and can only be carried out at the risk of damaging the fore and after parts with the blasts of the pieces. We reject in principle the use of blast screens, so easily destroyed by the rapid fire of the small guns, and, besides, it increases out of proportion the target presented to the fire of the enemy. In reality the lozenge-shaped arrangement only permits the use of either the forward or after gun, two on the bow or on the quarter, and three only abeam. One of the pieces is always unused in the case of a single object.

The arrangement in couples forward and aft allows, on the contrary, to bear always two guns dead ahead or dead aft, and four on the sides. It, therefore, realizes a superior offensive power with a gain in the difference of weight, since it uses only two turrets instead of four, and it is this arrangement that should logically prevail.

We have claimed for the primary battery the maximum of ballistic power by reducing to a minimum the number of the guns. On the contrary, we shall demand for the secondary battery that it be as numerous and as handy as possible, while preserving the sufficient ballistic power for the work it is intended to perform. As a rule the pieces of the secondary battery may be placed anywhere on board ship where their action is not hindered by the blast of the big gun. In the system of two guns forward and two aft that we have adopted, they will occupy to great advantage the central part of the vessel. The guns

nearest the extremities will be able to fire ahead or aft on each side of the turrets of the heavy guns. We think this arrangement preferable to that consisting in placing the fore and after guns of medium caliber on a higher deck. Its difficulty in such case of protecting completely their organs, as well as the necessity of reducing as much as possible the elevation above water of the man-of-war, makes it advisable to place all the guns of the primary and secondary battery on a level. The guns forward should, however, have a greater elevation than those aft, in order to be always serviceable in a heavy sea.

Thus, we save completely the upper tiers for the guns of the light battery, whose dominant quality is their rapidity of fire. There is no advantage in placing this battery very high, for its principal object is to fight the torpedo-boats, and, as such, their pointing in direction is the only one capable of rectification; the firing must be as flat as possible.

The fire of the guns of the light battery placed in the tops is necessarily unreliable, not only on account of the motion of the vessel, but also on account of their elevation above water, which at short distances would make a considerable angle of fall. These guns can only be effective in cases of vessels crossing against the unprotected personnel of the decks or bridges. It is doubtful if that object justifies the use of the fighting masts that support them and are exposed to be destroyed or upset in action by exploding shells, and thus become a danger for the vessel. The masting of armored battleships should only be intended for signals, and constructed so as to present as little target as possible to the shells of the enemy.

The efficiency of firing, apart from the caliber, depends on two factors: accuracy and rapidity. Theoretically, rapidity of fire takes only the second place, but in practice the chances of hitting the enemy increase with the number of projectiles it is possible to fire at him during the time, often very brief, he offers a favorable target. There is, therefore, a great advantage in improving the mechanism of the gun, so as to obtain a rapid fire, not forgetting that ammunition-hoists and passages must have the endurance, safety and simplicity required in the gun itself, besides giving a supply as rapid as the firing of the piece they serve. It is a mistake, we think, to seek the solution of the latter problem in the rapid motion of the hoist, which can only be obtained at the

expense of safety. Rapid firing being seldom sudden and unforeseen, and being capable in that particular case of being secured by the reserve supply, the movement of the ammunition coming up from the magazines can be a slow and continuous one, if care is taken to begin it in time. The supply of ammunition from the magazine will then be equal to that spent by the piece.

The rapid firing of the pieces of the secondary battery demands some discrimination. The tactical principle of firing as rapidly as possible the moment the enemy makes his appearance does not apply at sea. The regulating of long distance fire can, in fact, be only approximate, and, moreover, the moderate supply of ammunition on board cannot be renewed during the action. The rapid-fire guns of the secondary battery actually in use would have spent all their ammunition in two or three hours of active firing. It is, therefore, of great importance not to open rapid fire before having obtained the distance by slow firing, or when the flattening of the trajectory renders distance immaterial.

As a principle the heavy guns should only begin fire at the distance where its projectiles can pierce the armor of the hostile vessel. That distance determined beforehand, and which in most cases will be at the same time favorable for the fire of the second battery, will be considered as the fighting distance. The vessel superior in speed and armament will impose that distance on the adversary, in a circular combat, keeping at a safe distance from torpedo attack. In the contrary case, instead of running away, he will generally find it more advantageous to stand head on to the adversary, and if the latter will accept the crossing, he will naturally reserve the fire of his heavy pieces and the most active fire of all his batteries for the moment of crossing to the other bow. He will have determined before hand for the use of each gun on the most suitable projectile; and it is of interest to remark that the disposition in couples of the ordnance permits of the simultaneous use of the armor-piercing shell and the bursting shell at the proper time.

Without insisting further upon those considerations, we may sum up by stating that the primary qualities required from the vessel's batteries are rapidity of fire and flat trajectory. It follows that this ordnance cannot consist of mortars, the weapon of slow fire, and curved trajectory, requiring complete stability of platform and an accurate knowledge of distance. Mortars

could be of service in the attack of coast-defense works, and the bombardment of forts, but it may be observed that the vessel's batteries can be used in this special undertaking.

To complete what concerns the battery, it is fitting to speak briefly of the supply of ammunition, which in some sort represents the quantity of military power of which the vessel is capable. These supplies must be determined by the bureau of ordnance, and suited like the radius of action to the military rôle expected from the vessel. In no case can they be modified by the naval constructor, and their adoption must be insisted upon absolutely. The magazines must be situated below the water-line, and in the vicinity of the pieces. Finally, in order to facilitate as much as possible the supply of the gun, the ship's batteries should comprize only three calibers, one for the primary battery, one for the secondary battery and one for the light battery.

The Ram and the Torpedo.—The object of the heavy battery which is to sink the enemy's vessel by piercing the hull at the water-line is continued under water by the ram and the torpedo, which are intended to act by contact against the unprotected parts of the hull. The wounds made by these weapons are generally fatal, but their terrible efficiency is balanced by the difficulties encountered in their use. As a general rule, it is only as the result of a clever maneuver, and by taking advantage of the unforeseen circumstances of the conflict, or against a disabled adversary, that a vessel finds itself in position to deliver a blow with the ram, or to fire a torpedo.

The ram possesses, it must be confessed, in the highest degree the qualities of simplicity and strength that typify a weapon of war. The action by shock, practiced from the earlier periods, and made again possible through the bulk and speed of modern vessels, will remain for a long time to come one of the eventual factors of its fighting power. But it would be wrong to suppose that the ram wielded directly by the captain should be his principal objective during the combat, and the firing of the batteries or torpedoes left to somebody else. In all circumstances the handling of the vessel is made subordinate to the necessity of making the best use possible of all its weapons. It is the captain's part alone to combine their action, to fix the precise moment and the conditions of their use. In the generality of cases, he acts alone by the use of the gun; if he intends to use the ram,

he may prepare its action and intensify it by means of his heavy guns and torpedoes.

The captain who should propose as his sole object the attack by shock, would run the risk of witnessing the futility of his efforts. The maneuvering facilities with which, thanks to its twin screws, the modern ship is endowed, would permit it to avoid easily the immediate contact of its adversary as long as it remains manageable. Besides, the shock under great headway may be as dangerous to the assailant as to the assailed. It is a question whether the ram is not limited in its use to attack against a disabled vessel, rendered motionless by the destruction of its propelling power, or forced to follow an immutable course. Even in such case, it must not be forgotten that a vessel threatening another with its bow is in turn exposed to be stopped by a torpedo before attaining its object. The torpedo-launching tubes properly disposed forward, aft and on the sides, play thus a defensive part by creating around a vessel a zone always dangerous to invade. The automobile torpedo may be compared to a ram acting from a distance in all directions. This view of it defines better its tactical use than the assimilation that can be made of this weapon with a submarine projectile. Though it stands midway between the ram and the heavy gun, the slowness of its motion under water, compared with that of a projectile through space, does not allow of its easy training, the sights having principally to reckon with two unknown and uncertain factors, the course and the speed of the adversary. There will be always great advantage in making use of the torpedo at close quarters, with a big chance in favor of its success. The firing of torpedoes by means of submarine tubes makes its success more uncertain. We think it will be often found advisable to fix the tubes and leave with the captain the care of seeking a position favorable for firing the torpedo. However, in case of the ship becoming unmanageable as the result of damage to the engine, it would be an advantage to be able to train the submarine tubes.

Floatability.—Passing now to the study of the defensive arrangements or dispositions, let us state that their principal object is to secure the floatability of the ship threatened at the same time by the heavy ordnance, the ram, and the torpedo. Against the fire of the first, there has not been found up to this time, a better protection than the all around armored water-belt. The

minimum height of this belt is determined by the limits between which varies the water-line, according to the rolling or the lightening of the vessel as a result of the consumption of coal and stores. Against the penetrating power of the high-powered projectiles this armor must have a resisting capacity not necessarily commensurate with its thickness and its weight. Progress consists, as in the case of guns of heavy caliber in perfecting process of manufacture in order to produce a metal more and more light and resistant. There will be found great advantage in extending the belt up to the freeboard, with a decrease in thickness.

In the absence of an armor water-belt it is almost illusory to reckon upon a protective deck to secure the vessel's floatability. Useless in this case, if it is situated above the water, it becomes dangerous if it is below, for it obstructs the means of draining at hand. The protective deck must therefore be in turtle-back fashion, with the central part well above water, and the edges reaching below the water-line. It must be remembered, however, that the incline presented on the sides, makes it in that case vulnerable to the high explosive shell, whose bursting is most destructive on the line perpendicular to its trajectory. Even then it should never be used alone, owing to its being more dangerous to stability than the deck entirely situated below the water-line, one single leak being sufficient for the submersion of one whole side of its surface. It is necessary to complete its action with a belt of cofferdams rising on the sides above the water-line, and a cellular division of its upper parts.

However, as there does not practically exist a substance sufficiently light, obturating and incombustible to fill the cofferdams such a method can only reduce in a certain measure the effect of the impact of a projectile at the water-line, by limiting the entrance of water to a few cells situated on the side, and the heeling over that will result may become dangerous to the safety of the vessel if no means are found to remedy it immediately, and above all to drain the flooded compartments.

The defense must abandon the direct protection of the below-water hull against the ram or topedo, and try to minimize as much as possible the effects of the shock of those weapons. It tries to do it by means of the double bottom and the water-tight compartments, as well as by multiplying the means of pumping out the water. The sum of these arrangements, which concern

exclusively the constructor, should from a military point of view present all the characteristics of simplicity and safety in their working that we claim for all machineries intended for use during the combat. It is on this condition alone that they will aid effectively in increasing the defensive power of the vessel.

Protection.—It is possible to conceive in theory the possibility of securing in a complete manner the floatability of the vessel. By making itself unsinkable, however, the man-of-war would have only solved one portion of the problem of its defense. The high explosives of modern ordnance acting against its superstructures would soon paralyze its movements and render it perfectly helpless. It is therefore of the highest importance to protect on one hand the organs of the propulsion and gyration, and on the other hand the factors of the offensive power placed on the upper parts of the vessel, that is, the guns of every caliber.

The protection of the boilers and engines is secured by the water-line belt and the protective deck. The latter, of a doubtful efficiency from the floatability point of view, protects, on the contrary, with great efficiency against the direct impact of the projectiles all the interior organs of the vessel. The protecting effect of the armored deck has been further increased by the addition of a screening deck and a second horizontal metal deck, situated above the water-line. The space between the above two decks can be partitioned by a cellular system, and it is thus possible to separate entirely the hull from the upperworks. This separation, however, must not be so complete as to interfere with communications between those parts of the vessel, or hinder the ventilation of the lower compartments.

In what concerns the protection of the batteries, the first requirement is that the system be complete, that is, that it should extend to all the apparatus necessary for the working, loading and training of the pieces. It would be illusory to place part of the mount behind a shield and to leave exposed part of its essential organs. If, for instance, one of the tubes furnishing the water pressure for the hydraulic training apparatus is directly exposed to the enemy's fire, the armor, however thick it may be, protecting the body of the mount, only represents a cumbrous and useless weight.

For the heavy guns, necessarily situated as already explained forward and aft of the vessel, the system of closed and moving

turrets, with an armored tube protecting the ammunition hoist, seems best adapted to realize complete protection. The system, however, is not without presenting some objection. It is difficult to manage with sufficient accuracy the rotation of the turrets to secure in a perfect manner the pointing in direction. On the other hand, the impact of projectiles may cause the deforming or jamming of the organs of rotation, and as a consequence render the turret immovable. For those reasons, preference is often given to barbette turrets, fitted with a strong cupola in one with and moving with the mount. In both cases it is important to protect effectively the part extending between the central tube and the base of the turret (*con inférieur de la tourette*), when the latter does not directly rest on the armored deck. The thickness of the plates to be used depends entirely upon the angle at which they may be hit by projectiles. The receding and rounded forms of the cupolas and ceilings allow of their receiving a lesser thickness than the sides. The whole should be able, for the heavy gun, to resist the rupturing projectiles of the heavier caliber pieces, for we must not lose sight of the fact that this heavy ordnance is the principal if not the sole *raison d'être* of the battleship whose offensive power remains entire, or nearly so, as long as it (ordnance) is untouched.

It is only when the pieces of medium caliber are arranged as bow and stern chasers, on board cruisers for instance, that they can be enclosed in turrets or semi-turrets with any advantage. In principle, effective fire should not be sought in the axis of the vessel by broadside pieces, nor even to secure an extended arc of fire, by means of salient sponsons. In most cases of a running fight the chased vessel's object is to fall back on the main squadron or seek shelter in port. Its course forms necessarily with that of the chaser, an angle allowing of the latter using its broadside pieces. In very rare cases where the isolated vessel with plenty of sea-room is in a situation to run dead ahead before the pursuer, the latter is interested in bringing to bear the greatest number of pieces possible. Nevertheless, this consideration becomes only a secondary one, and gives way before the necessity of keeping up speed and direction in all passive weather, which can only be done with the sides even and free from the action of the waves.

We are, therefore, of opinion that the main battery should be

disposed in broadsides, behind an armor sufficiently strong to stop explosive shells.

The protection of these guns should, on the other hand, be completed by a system of ceilings, shields, and partitions forming casemates, and intended to minimize as much as possible the effects of the bursting of shells that have penetrated the interior of the vessel.

The light battery should with advantage be arranged in groups on the upper deck behind movable cupolas of sufficient thickness to resist the projectiles of similar guns.

In short, the final adoption of the rapid-fire gun of medium caliber necessitates the complete protection of all the organs of the fighting power of the vessel.

This obligation is principally made imperative for the automobile torpedo, whose delicate mechanisms could not resist the impact of the smallest projectiles. It is impossible to leave exposed to the fire of the enemy the compressed-air torpedoes without running the risk of witnessing the bursting of their air-reservoir. Those weapons can no longer be employed except in the protected parts and below water.

The organs of gyration, helm, tiller-ropes and servo-motors, must be carefully placed out of reach of the enemy's projectiles.

It is not enough to thus protect the machinery; the protection of the personnel who give them life, and could not be replaced during the combat, must be attended to with the greatest care. The captain must not leave the conning-tower (*blockhaus*), from which he directs the movements and the action of the vessel. Neither must the executive and other officers leave their protected stations without necessity. Moving about of the men under the fire of the enemy should be strictly forbidden, or take place only behind the armored sides of the vessel. This necessitates the establishment of a complete system of transmission of orders between the conning-tower and all the parts of the ship. The study of these transmissions completes in a certain way that of the system of ship's protection, and gives it all its value.

In order to realize the ever increasing importance of protection in a modern action one needs only to imagine to himself a duel between two ships, one armed with a powerful but unprotected battery, the other having but one piece of medium caliber, but realizing the most perfect protection of all its organs. Mani-

festly, the latter would, within a more or less short space, obtain the advantage.

The fighting capacity of a vessel cannot therefore be exclusively measured by that of its offensive weapons. Just as nautical capacity should seemingly be defined by "radius speed" (*vitesse rayonnante*) we shall, putting aside secondary armament, consider only as the characteristics of a ship's fighting power, its batteries protected in every part, counting in even the platform on which they stand.

Actual Antagonism of Nautical Capacity and Fighting Capacity.—We have briefly enumerated the dispositions constituting the fighting and nautical capacities of the man-of-war, and endeavored to formulate in each case the tactical conditions they must answer. It is evident that the type vessel of which we seek to conceive a model should join to the maximum nautical capacity realizable the maximum fighting power possible with the data of modern science. Before examining if the construction of such a vessel is possible let us cast a retrospective look at the sailing vessel constituting, in the beginning of this century, the tactical unit of war fleets.

Nothing could be less exact than to consider the modern fighting ship as a simple improvement upon the ancient man-of-war. No doubt that a comparison between the smooth-bore gun and the pieces of modern batteries is impossible. On the other hand, it is just a waste of needless time to refer to the superiority of the powerful motive engines of the present over the sails and masts of old. Nevertheless, from a tactical point of view, we have taken occasion to remark that finding its motive power in all parts of the globe, the sailing vessel had an almost unlimited radius of action. Its speed, depending exclusively upon its perfection of forms and its exterior sail area, could surpass that of the swiftest of merchant vessels. Its nautical quality was thus carried to a possible maximum without in the least interfering with the development of its fighting power. The latter having, so to speak, a displacement greater than the weight of the pieces it was materially possible for it to carry, could easily attain by increasing the number of its gun-ports, the maximum compatible with the tonnage of the vessel.

To speak the truth, this conception was only completely realized by the frigate. The two and three deckers encumbered

themselves with dunnage detrimental to speed, in order to increase their fighting capacity. However, though we see thus appear from that epoch of the unavoidable antagonism between nautical and fighting capacity, it is undeniable that the sailing navy had reached its highest degree of perfection in an almost perfect harmony in the divers factors of its power.

The first appearance upon our vessels of the steam engine marked the point of departure of a new era, of a series of conceptions and dispositions destined in reality, not to perfect but to replace the old navy, by substituting little by little iron and steel to the materials used formerly in the construction of our vessels. We witness only to-day the complete disappearance of masts and the definitive *début* of the entirely metallic vessel. The various elements of its power are incomparably superior, taken separately, to those of the old ship, but if it has a right to expect everything from the progress of metallurgy, the modern ship cannot excel them. It meets at the beginning of its career with a difficulty, at present insurmountable, resulting from the antagonism necessarily existing between its nautical and fighting powers. Let us suppose in fact a hull of a determined form and displacement and let us propose to give it the greatest nautical power possible, that is the greatest radius speed it is possible to attain. It is evident that the vessels having only to consider the internal energy it carries along, the heavy motive apparatus and the fuel necessary for their action, will occupy the sum total of the load exponent. Every weight proper to the offensive and defensive arrangements will have a counterpart in the decrease of the radius of action. If, on the contrary, we wish to obtain the maximum fighting power, the weight of the guns, and their mounts, the turrets, the deck and the armored sides, will soon in turn equal the totality of the available displacement. In the first case, we have built a vessel of great speed but harmless; in the second, we have a powerful one but nearly stationary. Evidently neither of the two answers the conception of a man-of-war, and it is needful to fight the enemy on the water.

Battleships and Cruisers.—How then shall be solved the problem before us? Will it be done by a compromise between the two terms of the power, giving us a vessel with speed and fighting capacity, and having consequently a diminished power in regard to both speed and armament?

We do not think so. The tactician proposes to himself, as we have already explained, to conquer the dominion of the seas in a determined region, that is, to maintain free communications for himself, and prevent those of the adversary. In order to maintain intact those communications he must have the most powerful vessels from a fighting point of view, and in order to paralyze the movements of the adversary he must possess vessels of greater speed.

Now, it would be unreasonable to demand from the constructor vessels that would at the same time possess high speed and be formidable in armament. It would be useless to try to obtain this result by a considerable increase in the displacement and, as a consequence, in that of the available load exponent, for the difficulty in realizing in a complete manner, as necessary, the protection of the organs of the offensive power, increases rapidly with the dimensions of the hull. The solution consisting in laying aside complete protection, in building, like some powers, large vessels incompletely protected, but with great speed, and provided with a powerful battery, is bad and should be rejected. However fast and powerfully armed these vessels may be, they could not contend for the mastery of the sea against vessels, slower it is true, but armed as powerfully, and with their guns protected by heavy armor.

We are thus forced to admit that the modern vessel must be twofold; that the tactical units of our fleets should actually be composed of two factors: the battleship (vessel of the line), possessing fighting power charged with maintaining freedom of communications; the cruiser, with nautical power whose duty would be to intercept those of the adversary. This point being conceded, it should again be affirmed that the separation of these two powers cannot be absolute nor lead to the assembling together of vessels heavily armed, but deprived of speed, and of rapid cruisers without any serious fighting capacity. In reality, we ought not to require in our battleships the greatest quantity, but only the greatest intensity, if we may thus express ourselves, of fighting power. For instance, supposing that the 305 mm. gun is actually the most powerful piece in our batteries, a battleship should carry at least one gun of 305 mm., of which every organ, including the platform on which it stands, should be effectively protected.

The quantity of power can then be increased by increasing the number of vessels. We have seen, on the other hand, that there is an advantage in making four, two forward and two astern, the number of heavy guns, of which it is feasible to completely protect the organs. That primary and necessary condition of the battleship being fulfilled, we will require the constructor to give it the minimum radius of action strictly indispensable for the duty it is to perform, which duty we will have fixed beforehand in absolute manner, and finally, the highest speed, whatever it may be, consistent with its displacement.

On the other hand, if 23 knots, for example, is the highest speed that the best cruisers or ocean-liners of the adversary can make, the cruisers of our squadron should join at least that speed of 23 knots with the radius of action fixed in advance necessary for their special duty, and we will require, moreover, the constructor to provide them with the most powerful protected battery possible.

We see how the terms of the problem fix themselves logically. In either case we cannot coerce the constructor in all the elements of his work. We must leave to his discretion, for battleships, speed, and for cruisers armament. We will simply consider as most perfect the battleships, which without sacrificing any of their fighting powers will have the greatest speed, and the cruisers, which without any loss of speed, will carry the most considerable battery.

For both the greater benefit of the appropriation money will result from the highest ratio obtained, without crowding or overloading, between the total power and the displacement.

We may add that the tactical unit cruiser is only transitory. Its two terms will fatally near one another till they merge together at some distant date, when by the use of a light but tough metal, they will sink their elements into one single type.

Specialization of a Man-of-war.—The fighting ship, be it a battleship or a cruiser, admits, therefore, of all the factors of fighting and nautical powers, but only some of those factors, protected batteries, or radiating speed, attain their maximum intensity, in order to constitute the dominant quality of the vessel, and range it in one of the two great categories we must needs establish.

Some have sought to push further this division of work by

specializing the man-of-war, by preserving, for instance, one of its elements of power, and minimizing or even neglecting all the others. Thus is obtained a craft of reduced tonnage, and still very effective from the special point of view it seeks to realize. Among the experiments of that kind which, by the way, have all been more or less condemned in practice, we must cite, first, the torpedo-boat, whose fighting capacity is constituted by one single offensive weapon, and whose nautical power only consists in high speed. The absence, on the one hand, of protection of any kind, and, on the other, the reduction to a minimum radius of action, remove the antagonism of the two powers, and constitute, for a short time, it is true, but with small and economical dimensions, an elegant solution of the naval problem.

It must be confessed, however, that at the present time the torpedo possesses but one of the qualities of a weapon of war—efficiency. It cannot without great risk remain exposed to the fire of the adversary; it requires minute and frequent regenerating; it is subject to breakdowns; in reality, it is neither safe nor simple nor robust, and may fail at the very moment when its use would be required. On the other hand, and in spite of improved sighting devices, the firing of the torpedo is uncertain and should be only practiced at short distances.

Now the torpedo-boat deprived of any protection cannot, in spite of the diminutive target it presents, approach the vessel it attacks without running a most serious risk. This risk is so great with the adoption of rapid-fire and flattened trajectory, that it must renounce day attack and resort only to night action and surprise. Let us add that it is obviously deficient in navigability, an essential quality in all kinds of war crafts. A heavy sea causes a loss of speed and embarrasses considerably the working of its weapons.

Thus, the torpedo-boat is far from being the formidable adversary it is supposed to be for battleships and cruisers. If we even reflect that its tactical speed is not very superior to that of battleships and cruisers, which, by opposing their sterns, may maintain it for a considerable time, under a destructive fire; that besides, theoretically, a surprise is next to impossible; one is forced to the conclusion that if it is not fated soon to disappear, like the ancient fire-ship, the modern torpedo-boat must be modified. It must improve the weapon it carries, and find the

protection it lacks, by becoming a submarine, or at least by becoming practically submersible at the moment of attack. It would be premature to consider the consequences following the solution now in sight of such a problem. Quite different is the conception of the ram, of which the only weapon possesses, as we have already remarked, the sum total of the qualities required in a weapon of war; that is, simplicity, safety, force, efficiency and can, besides, realize the absolute protection of its motive organs. However, we have already called attention to the difficulties presented in an attack by shock. The ram being, on the other hand, entirely powerless against an adversary of superior speed, can only acquire the rapidity it lacks without losing any of the complete protection, which is its *raison d'être*, by attaining dimensions proportionate to the vessels it assails. Hence, we are led unavoidably to utilize it with more guarantee, by fitting it with torpedo-tubes and a heavy battery.

The ram thus modified fatally becomes, with an increase of speed, the battleship of our squadrons, or with a lesser speed, the armored coast-defense vessel, whose principal mission is to serve as an auxiliary to the coast batteries, constituting the tactical unit of the coast-defense fleet.

We see that the tentative specialization of the man-of-war, with the object of minimizing dimensions, is fatally doomed to failure; it is impossible to seek a middle term between these two extremes—the submarine and the battleship.

We will, therefore, mention only *en passant*, two other specialized types of fighting ships, the *bateau-canon* and the mortar-dispatch-boat (*aviso-mortier*), though their conception awakened a certain interest.

These vessels, like the torpedo-boats, rely for nautical power on a momentary spurt, and for fighting power on a single offensive weapon deprived of any protection. The "bateau-canon" carries simply one piece of medium caliber, which is powerless against the armor of a battleship or even a cruiser. It has all the defects of the torpedo-boat without, like the latter, the advantage of an efficient arm and the ability of submersion. We will repeat the same about the "aviso-mortier." We can certainly easily imagine a light vessel armed with a mortar of large caliber, throwing a projectile charged with a powerful explosive, a sort of torpedo-ball, of which the impact would produce in

the upper works of a battleship a considerable destructive effect. Such a vessel is a veritable torpedo-boat, condemned, like the latter, to act under the cover of night by surprise and at short distances; for mortar-firing with curved trajectory, requiring perfect stability of platform, is out of question on a small vessel.

As to the bombardment of fortified places, it seems that the vessels of the squadron with their staunchness, their protection and radius of action, are far better qualified for this work than the light crafts referred to, which are, besides unable to keep up the blockade in heavy weather, however great their number. Let us then lay aside the dream of the naval dust (*poussière navale*), and maintain, with the majority of officers, the necessity of large vessels at once weatherly and powerful, alone capable of gaining the control of the seas.

Before finishing, we will say a word about a class of vessels which are not properly fighting ships, but which, nevertheless, can render the latter important service. We refer to those crafts which, doing away with fighting power only, preserve as high a speed as is obtainable, combined with a limited radius of action, and among which we will range the estafette, which serves as a link between the two constitutive elements of our fleets, the battleship and the cruiser. Such a vessel, with a sufficient displacement to enable it to maintain speed in moderate weather, is not intended to fight even vessels of similar size, and its exclusive mission is to carry to their destination the orders and information it is the bearer of, by quickly falling back upon the group to which it is attached.

If found expedient to do so without interfering with its nautical power, it can be armed with rapid-fire light pieces to act against torpedo-boats. The estafette, otherwise called despatch-boat or scout, is in some sort the link of the tactical unit cruiser-battleship, and allows the latter to develop all its capacity without a disjunction.

Finally, it should not be forgotten that war on commerce, in spite of the secondary rôle assigned to it, completes the programme laid out for our rapid cruisers, the object of which is to intercept the adversary's sea communications. It would, in such case, be advisable to adjoin, to the latter, vessels capable to act efficiently against merchant vessels, that is, having great nautical capacity, with a certain fighting power. The impressed

ocean-liners, fitted with a limited number of pieces of medium caliber, will be useful in this capacity. It is important, however, to observe that the commercial routes must not be abandoned until the enemy has obtained undisputable control of the seas. Although reprovisioning along the seacoasts can be done under neutral flags, in most cases it will be found more advantageous to use for that object the national or home merchant marine.

In a theoretical sense, therefore, it would hardly be a wise policy to divert, at a heavy expense, from their exclusively commercial calling, the steamers of our great transatlantic companies. It would seem preferable to build and have ready special vessels of great tonnage, having great speed and a large radius of action. Some of these destroyers, ordered at the breaking out of hostilities to convenient points, would render great service by paralyzing or at least momentarily embarrassing the commercial shipping of the adversary.

THIRD PART.

MODERN FLEETS.

The First Line Squadron.—Squadrons are reunions of vessels intended to act simultaneously, that is, capable in all circumstances of concerting their movements and actions.

The tactical unit being necessarily composed, as already demonstrated, of two terms, the battleship and cruiser, combining their powers to obtain in its totality the supremacy of the sea, the squadrons will be composed in equal parts of battleships and cruisers.

The squadrons of the first line, which are the highest manifestation of the country's naval power, and are destined to meet the first shock of the enemy, will include the battleships possessing the greatest degree of fighting power joined with the highest possible speed, and the cruisers, whose nautical capacity is superior, or at least equal to that of the adversary's cruisers, and which are, at the same time, provided with an armament and a protection as complete as possible. Swift battleships, with armored cruisers, connected by means of scouts of high speed and seaworthiness, thus constitute the only theoretical elements of such a fleet.

However, by the very reason of the increasing and parallel progress of all branches of navigation, the most recent vessel of each type alone possesses generally all the power resulting from the late progress of metallurgic science, and it could hardly be otherwise. The putting on the stocks simultaneously a great number of vessels of the same design, followed by a forced suspension in the construction, would result in a squadron which, after a few years of active service, could only offer inferior types against the more recent units of the adversary. The constructor, in fact, is powerless to modify his work. Retouchings practiced with great discernment, changes in the batteries or boilers, doubtless may improve considerably the vessel from the fighting point of view; it could only very rarely increase its nautical power, that is, the ratio of its capabilities.

The tactician is confronted in practice with men-of-war of various types and capacities, from among which he must pick out carefully the units of the squadron of the front line, capable always of combining their movements for a common aim.

Of Homogeneity.—In order to concert their action in all circumstances, the vessels of a squadron should be homogeneous, and it is important to know what is understood by this homogeneity, we demand as the quality necessary, but sufficient, of the units intended to constitute the front squadron. We have just seen that it can not be expected that these vessels should be similar. Bearing besides in mind, according to the axiom formulated in the beginning of this study, that the fighting power of a fleet equals the sum of the fighting powers of each one of the units composing it, let us remark that from a strictly military point of view it would seem that we would have an interest in getting together the greater number of vessels possible, whatever their capacity.

Not at all; we know, on the other hand, that the nautical power of the whole exactly equals that of the vessel having the least. The addition of a vessel having an indifferent nautical power reduces, then, to this indifferent value the nautical power of the whole fleet, and the resulting tactical inferiority may balance largely the advantage derived from the fighting capacity of this single vessel. Thus we see that it is necessary to pick out the vessels intended to form the squadron of the front, exclusively among those that possess the requisite homogeneity of nautical power.

From the point of view of navigability, for example, it is evident that all the vessels of the squadron must be able to weather the same gales on the high seas. If one of their number is obliged to seek shelter, the whole squadron, unless it ceases to act in concert, that is, as a squadron, must follow it.

We are forced to the same conclusion in regard to the radius of action, which is, as already seen, the first determinant of the man-of-war, and, consequently, of the squadron. The expected effort of a squadron in time of war demands that it be able to sail, at a fighting speed or economic rate, a given distance. The battleships taking the shorter course, the cruisers should spread in order to form divisions of contact, chase and reconnoissance, and hence sail over a greater distance than the battleships, although a distance also previously fixed upon. The scouts' duties being, on the other hand, to keep in touch with the various fractions of the fleet, they will have a still greater radius of action proportional to the first two. It is not our place to find out here what should be the relation and absolute value of these three radiuses of action of which the sum total constitutes the radius of action of the squadron of the front, and is determined by experiments by the commander-in-chief in time of peace, according to the object proposed in time of war. This determination, we repeat, should logically precede the conception and construction of the vessels intended to compose this squadron, and it is clear that we can afterwards adjoin to them only vessels having at least an equal radius of action. We must rigorously exclude those vessels that might lag behind precisely at the very moment of executing the principal strategic scheme for which the squadron was constituted, as well as the cruisers and scouts which could not fill their mission to the last moment of the projected operation.

It is hardly necessary to add that all the vessels of the squadron must have supplies of victuals, fresh water and coal, for the same length of time. The provisioning of that nature, as well as on the other hand the steaming coal which would be in excess only in some of the vessels, would represent exclusively for the latter a useless weight, stowed and carried at the cost of the real power.

Finally, we must argue in the same way touching speed.

The fighting speed, or tactical speed of the squadron, can

only equal that of the slowest of its vessels. We will have, therefore, to consider that the superior speed of the newest types can only be made use of in exceptional cases, and, on the other hand, we must exclude vessels whose slowness would give to the whole a manifest tactical inferiority. This last consideration applies equally, and even with more force, to the cruisers and scouts, which can always find opportunities for superior speed, but which in case of inferior speed would be for the squadron an encumbrance instead of a help. To sum up, the homogeneity of nautical power that we demand for all the units of the squadron consists in the judiciously regulated harmony of the three factors—navigability, radius of action and speed—and we must state that such harmony can only be realized on vessels of a large tonnage. Though scouts may reduce to a minimum their fighting capacity and devote only an insignificant fraction of their load exponent to armament, the necessity of obtaining great speed, a great navigability and a radius of action far superior to that of the *corps de bataille* for which they must reconnoiter, necessarily leads to a considerable displacement, which it seems to us cannot remain inferior to 4000 or 5000 tons.

Light Divisions.—We are thus logically induced to exclude from the squadrons of the front line all light crafts, torpedo-boats, destroyers and despatch-boats, which in time of war can only be for them an encumbrance and even a danger. There will no doubt occur certain circumstances when a squadron will find it advantageous to make use of torpedo-boats, and in that case the commander-in-chief will have in readiness light divisions, independent, stationed at determined points that will, in his direction, lend their special cooperation to the general plan; but these purely strategic combinations have nothing to do with the tactical conception of the squadron we seek to realize, and which could only include, under the name of light division, the assembling of scouts of large tonnage above referred to.

Torpedo-boat destroyers accompanying a squadron can only be of certain use in exceptional cases. Their small radius of action renders them unfit for scouting duties, and, on the other hand, they are more embarrassing than useful in a surprise night attack by torpedo-boats. We are therefore of opinion that their place is elsewhere, and that their rôle consists, above all, in acting singly against the coasts and mobile defenses of the enemy.

The Reserve Squadron.—Though the squadron of the front line may only include vessels of recent construction, possessing the desired homogeneity of nautical power, it does not follow that the tactician should condemn the older units or units of different types. Those vessels of the second order will, with the homogeneity peculiar to themselves, constitute the reserve squadron intended to play, in time of war, a determined and considerable part. It is wrong to think that this squadron will be added with advantage to the active squadron at the opening of hostilities. More likely it would bring with it an element of weakness and embarrassment, and it will be preferable to go into action with a less numerous but homogeneous and swift force.

Moreover, the constitution of strong reserves is as necessary to a fleet as to an army, and the commander who should be willing to do without them would commit the same blunder as the general who should engage all his troops at the first shock, thus exposing himself to the risk of seeing his first check turn into a complete and irreparable rout. It is certain that the shock of the squadrons of the front lines will have but very few vessels unharmed. Victory at sea does not generally consist in occupying or keeping certain positions; it belongs to that one of the two fleets that is the least crippled in action. Only fleets of old times could, after a victory, continue their cruises or operations. Nowadays—numerous and recent examples prove it—it is very likely that victorious and vanquished alike will run back to their respective bases of operations to repair damages and refit, and will for several months to come be unable to go to sea.

Then the reserve squadrons will line up. It can be affirmed that the real victory with all its consequences will belong to the one country that will have reserved for that moment a fleet capable, after the meeting and disabling for the time being of the squadrons of the first line, to become undisputed mistress of the sea.

The Defense Fleet.—Though inferior from a tactical point of view, the reserve squadron should possess a characteristic homogeneity which alone allows it to concert on the high sea the action of its various units.

The coast-defense fleet, on the contrary, can accept and utilize vessels of the most dissimilar types. It has, in fact, to concert

its action only with that of the forts and coast batteries, and requires only an insignificant nautical power. Always within call of the navy yard and its magazines of all kinds, it can incessantly renew all its supplies. The commander of the coast defense fleet is the commandant of the navy yard, who resides ashore and commands the whole of the sea and land defenses of the place. He has no other care than to utilize, according to their special capacities, the vessels placed under his orders, and which find naturally their places in the organization of *ensemble* of which we have already sketched the main outlines. Thus, for instance, he disposes of the torpedo-boats to guard the passes, protect the coast landings, pursue and harass the assailing forces, but which he will carefully avoid employing as scouting duties, for which the torpedo-boat, with its limited sight and smaller endurance, is as little adapted as possible. The real scouts of the defense fleet are the semaphores of the coast, and these can be aided by some light crafts whose duty would be to reconnoiter rapidly outside, and communicate with the signal-stations. The torpedo-destroyers will, besides, protect effectively the slow-going defense boats, obliged to remain stationed off shore.

The coast defense fleets, and particularly the mobile defenses, will incidentally lend their aid to the sea-going squadron in case of the naval action taking place near the base of operations.

The Remote Divisions.—The active squadron, the reserve squadron, and the coast-defense flotilla constitute the three necessary echelons of the properly called fighting fleet, the object of which is to maintain intact the approaches to the coasts and to gain the supremacy in the home waters. After securing this primary object, we know that the navy has another duty to perform in looking after the interests of the country over all those parts of the globe where they are threatened.

Naval operations in distant seas may be only an extension of the strife carried on in European waters between two powerful neighboring countries. In such a case both adversaries will find it to their interests to maintain near their own coasts the three echelons of their large sea-going vessels, and to send to distant stations only cruisers of great nautical power. These cruisers will be grouped with advantage in time of war into divisions of homogeneous cruisers, the duty of which shall be to

protect the colonies and national commerce, as well as to attack the colonies and the commerce of the adversary. Their activity shall be exercised within determined grounds, between the limits marked by the fortified bases, where they can replenish their bunkers and secure supplies of all kinds.

Distant naval warfare presents quite a different aspect when directed against barbarous or semicivilized nations. Against natives, deprived of all means of action at sea, light-draft vessels, capable of sailing up the rivers, will do good service. They must be immediately put out of commission in case of a European war so as not to tempt the enemy with an easy triumph. When the adversary has a navy, it is clear that the fleet intended to attack it must be strong in proportion to the power of that navy, and if the contention is against real squadrons composed of modern battleships and armored cruisers, it is evident that they must be opposed by similar units in the foreign stations where naval action is intended. In this case, cruiser divisions are totally inadequate, and it is incumbent to replace them with squadrons, a thing only possible on condition that the points of support of the foreign fleet are increased proportionately to actual dockyards capable of serving as their bases of operations.

Points of Support of the Fleet.—The transformation of the old fleets lost to them in great part their independence of movements and action. It is not altogether the capital question of combustible that prevents them from remaining long at sea, and generally forces them only to move in order to go from place to place as economically as possible. The necessity of renewing their war ammunitions forces them to call at the only place where stores of these ammunitions have been established in advance. Modern vessels cannot, on the other hand, repair themselves on shores in every part of the globe. They must find the special tools required by the different pieces of their engines and their auxiliary apparatus, and the least injury to their hulls forces them to go into dry dock. Finally, their repairs in other than home docks is justly considered a violation of the laws of neutrality.

Without insisting any further, let us state that no modern fleet can do without a unique and fixed base of operations where it can run for shelter, revictual and repair, that is to say, find the special supplies and the particular implements it needs. It can be said that the navy yard forms now an integral part of the

fleet; that it is its natural and indispensable complement, and in order to completely fill the part assigned to it, it should be, in the first place, a stronghold defended by land and sea against any surprise attack. Not only must the shops, wharfs, stores and refitting docks be placed beyond the range of the enemy's projectiles, the roads themselves should be strictly closed in order that the vessels anchored there may with perfect safety dismount their engines and examine their apparatus. It is on this condition alone that the dockyard is truly a support and base of operations where the fleet can find in every form the energy needed to move about and to fight.

Convoys.—The close bond existing between fleet and dockyard constitutes a tactical inferiority that must be minimized by all possible means. With this object in view, it seems in the first place an unquestionable utility to establish a great number of coaling stations in those quarters where the presumed action of the naval forces will take place. It must be stated, however, that unless these stations are fortified, they are fatally doomed to fall into the power of the enemy. The necessity of so combining the movements of the fleet as to give it a chance to take advantage of these stores, naturally impedes greatly its operations. It is likely, then, that the problem would be solved with greater certainty by the adjunction to the squadron of a supply-convoy, that is, of a convoy loaded with coal, victuals and ammunitions, with the additional duties of taking on board the sick and wounded, and, if need be, of furnishing fresh personnel or exchanging. Tempting as this idea may be, we confess that it would be well-nigh impracticable as long as the fleet has not practically obtained the supremacy of the sea. In order to avoid the risk of being captured at night by the enemy's cruisers, the vessels forming the convoy would have to be placed in the center of the fleet, and it can be easily realized that in case of surprise, this formation would be a disadvantage. On the other hand, in order not to delay the fleet, the convoy must have at least the homogeneity of nautical power of the battleships, a condition that would likely necessitate a diminution in the loads to carry. It will be always prudent to delay operations requiring the adjunction of a convoy till the hostile fleet is defeated, unless the adversary refusing general combat by squadron, it may become necessary to force it upon him by indicating a movement against his coasts with the combined forces.

The initial and dominant fact of the hostilities should be the shock of the hostile squadrons, but this shock will be always followed, if not preceded, by operations of a secondary order, as blockades or landings necessitating either convoying of supplies or transportation of bodies of troops. It will be important, therefore, to prepare beforehand the organization of these convoys for which can be employed the chartered ocean steamers, and, better still, vessels specially built and equipped for that purpose.

Independently of the properly called convoy, repair transports, hospital ships or torpedo-boat transports, will render good service to a squadron on condition of possessing a sufficiently great nautical power in order to be always able to accompany it or withdraw in time from the field of battle.

Conclusions.—It seems impossible to study the problems of naval tactics without first sketching the general outlines of a plan of *ensemble* admitting of an exact notion of what should actually compose fleets of war and of what should be required of them.

In seeking to constitute logically the forces that we will have to put in motion, we have endeavored to set off what to us seem the essential features of a modern navy, to wit, the actual antagonisms of the nautical and fighting powers, and the limited field of action of the fleets resulting from them.

No doubt but some day this antagonism will disappear. The vessel, without losing any of its fighting powers, will become swifter and swifter, and the cruiser, without any loss of nautical power, will have a more effective armament and protection.

The two factors of the tactical unit will tend more and more to merge together, and will finally constitute the unique type answering all the needs of maritime warfare. Then the fleets will become identical. The home squadrons and the foreign divisions will possess the same homogeneity and form on a single fleet capable alike, as former fleets, to operate in distant stations or on the immediate coasts of the country. It would, however, be a mistake from a tactical point of view to try to anticipate progress by a premature conception of vessels and fleets, which, in order to be adapted for every kind of service, would inevitably be actually condemned to an inferiority of one or other of their powers.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON CUBAN PORTS.

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Cuba, from its size and situation, may well be considered the most important of the West Indian Islands. Laying aside the question of its wonderful fertility as a matter connected with the peaceful concerns of the inhabitants, it becomes necessary to investigate the possibilities that the island presents, as affording bases for hostile operations against the United States, or as locations from which to meet and ward off such attacks.

Placed at about the same distance from the peninsulas of Florida and Yucatan, it is the natural sentry-box to the Gulf of Mexico and to the waters washing the shores of Yucatan and Honduras. The nation that holds its ports, in force can, at its will, dominate over those waters and control ingress to and egress from the ports therein. The interest of the United States in the Gulf is vastly in excess of that of all other nations combined, and it behooves our country to make certain that, by no chance or oversight, any coign of vantage in Cuba be allowed to fall into the possession of a State that may antagonize those interests.

It is the object of this paper to attempt to investigate the natural facilities of the island for naval war purposes, either offensive or defensive, and to this end a critical examination of the coast and adjacent waters seems to be first in order.

From Cape Maysi, following the northern coast, there is no harbor of any magnitude or importance until the entrance to the bay, on which are situated Carbonico and Livisa, is reached. Here we find a clear entrance of 200 yards in width, which divides, at about half a mile from the mouth, into two arms

leading to two separate lagoons. The eastern passage is very tortuous but clean, giving access to a lagoon having an excellent anchorage ground, of at least 5 fathoms depth, of a mile and a quarter in the east and west direction, and with a least width of 700 yards. The western passage opens into a lagoon many times broader and deeper, but much cut up with shoals. There is, however, an abundance of good anchorages for deep drafts. Both of these harbors are protected from wind and sea in all directions.

Five miles to the westward of this is the entrance to Port Nipe. This entrance has a least width of 500 yards and is clean throughout. The anchorage ground for deep drafts has an area of about six square miles, unobstructed by shoals. From the numerous rivers entering the bay, it would seem that a bountiful supply of fresh water is available. This harbor is about 90 miles, in a W.N.W. direction from Cape Maysi. It is protected from wind and sea in all directions. Between the 5-fathom and 3-fathom curves there are several square miles of clean anchorage for light-draft vessels. The depth of water in the narrow entrance, together with the strong current setting through it, would seem to preclude the placing of mines therein, though such fields would be practicable between Punta de Mangle and Punta Santa. This harbor seems exceptionally strong in a defensive sense and could be made impregnable with but a moderate outlay of labor. Batteries on the bluffs on Punta Roma, and on the south shore of the canal, would command the entrance at exceeding short range. The sole objection to Nipe as an ideal natural formation for a base arises from the narrowness of its entrance, which prohibits exit save in a contracted front. At most, but three battleships could emerge in line. The approach is well marked and access easy.

Port Banes, nine miles to the northward and westward of Nipe, presents another excellent harbor with a narrow and tortuous entrance. Its vicinity to Nipe, however, takes away from its importance, as the superiority of the latter is so marked as to dominate its neighborhood. The narrow and crooked channel would render it hazardous to attempt entrance with long ships.

Port Naranjo, about ten miles west of Sama Point, offers anchorage as a port of refuge, but presents few of the requisites of a safe and permanent anchorage for a fleet.

Port Padre, 47 miles to the westward of Sama Point, affords a secure anchorage for vessels of moderate draft. It is entered through a channel varying from one to three cables' length in breadth, and three miles long. It possesses no qualifications as a naval base, except those of security and space; the depth of water is insufficient for battleships.

From Port Padre to the westward, we find no harbors for deep-draft vessels worthy of consideration until reaching *Port Nuevitas del Principe*, which is entered through a narrow and crooked channel six miles long, opening out into a broad lagoon in which there is bountiful room for the anchorage of craft of moderate draft, but with only moderate accommodations for those of deep draft. The difficulties of the entrance would prohibit its free use for these latter.

From here to Cape Frances there are no harbors, and but one or two spots at which anchorage for small vessels is safe and secure. It is noted that *Buenavista Bay* is uncharted, but it probably resembles the other bays extending inside the line of Cays. At *Cay Frances* is found anchorage in 5 fathoms.

Sagua la Grande affords excellent and spacious anchorage to vessels of 15 feet, and is approached through the usual narrow and long entrance.

Cardenas Bay is navigable only to vessels of light draft and not exceeding 11 feet.

Port Matanzas is an indentation of the coast, some five miles deep. Opening to the northward between Point Maya and Point Sabanilla with a width of three miles, it gradually narrows to about one mile at a mile from its end. Here is to be found the anchorage ground with shoals to seaward and restricted for vessels of deep draft; a limited area of anchorage is found outside the shoals. With its broad mouth open to all winds from the northeast quarter, the anchorages must be very unsatisfactory. Matanzas does not present features such as would recommend it to the military eye for a base. It would be impossible to mine the approach.

From Matanzas to Havana the coast runs in an almost unbroken line, yet it was here, at a point about six miles to the eastward of the Morro of Havana, that the English expedition of 1762 against Havana was disembarked. At the mouth of the

Cojimar River, three miles east of Morro Castle, the end of one of the cables connecting Havana to Key West is landed.

The *Harbor of Havana* is so well known that it need not be described. Though the anchorage space for vessels of deep draft is very constricted, so well is the harbor protected from wind and sea that close berths for ships may be safely occupied. The harbor is capable of an almost perfect defense, by means of dominating batteries and mines. The city itself lies open to bombardment from seaward.

At Chorrera harbor, four miles west of Havana, one of the cables to Key West is landed.

Port Mariel, about 20 miles to the westward of Havana, affords access and anchorage to vessels of moderate draft; a shoal part of 4 fathoms depth in the entrance, and the narrowness (50 yards) of the channel preclude its use for deep drafts. The chart would indicate a sufficiency of good anchorage for a numerous fleet.

Port Cabañas, twelve miles west of Port Mariel, offers excellent anchorage of sufficient depth and area, after passing through the entrance canal, in which is a bar with but 3¾ fathoms of water. A new survey might develop changes at this point, which might add vastly to the importance of the harbor as a port of refuge or as a base.

Port Bahia Honda has a limited area of anchorage for deep drafts and could hardly be developed into a strategic base, were its situation even the most favorable.

From Port Bahia Honda to Cape San Antonio the coast is skirted by cays and reefs, through which are occasional openings, admitting vessels of light draft to the enclosed lagoons. These latter are mostly shallow and are cut up by numerous shoals. Some few safe ports and anchorages for small vessels exist.

The lagoon immediately to the northward and eastward of Cape San Antonio seems to hold out the possibility of a good, safe and convenient anchorage for a large fleet. Should a future survey demonstrate the existence of a sufficiently deep channel through the reef in this vicinity, these enclosed waters may become of the greatest strategical importance, situated, as they are, at the extreme end of the island, whence a fleet could operate with the least delay on both coasts, and would be able to hold the Yucatan channel under the closest espionage.

From Cape Maysi to the west, on the south shore of Cuba, the first port is that of *Baitiqueri*, which admits only vessels of light draft.

Port Escondido is of small extent, though the depth of water is said to be sufficient for deep-draft vessels.

Port Guantanamo, twelve and a half miles west of Escondido, is a deep and complex indentation. Its extreme depth is about eleven miles, though the greater part of this is available for anchorage to light drafts only. The entrance to the port has a clean width of 12 cables' length, which narrows, off Fisherman's Point, to 7 cables' length. (For general description of harbor, see "Sailing Directions, Caribbean Sea, etc.," No. 86, Vol. I.) The size, situation and facilities of this port at once commend it for consideration, as a main base for naval operations connected with the islands and waters lying to the southward and eastward of Cuba. In capacity, depth and security of anchorage, and capabilities for defense and offense, it would seem to possess nearly every requisite in demand for a main station. Proper batteries erected on Windward, Fisherman's and Leeward Points would completely command the channel, and the moderate depth of water in the entrance would permit of placing any number of mines. In the middle reaches of the bay there is good and sufficient anchorage for transports and supply vessels, safe from any possible gun-fire from seaward. Numerous inlets and arms afford excellent havens for the smaller war vessels and torpedo-boats.

The port of *Santiago de Cuba* is an inlet extending nearly five miles in a general N.N.E. direction. The entrance is barely 200 yards in width at its narrowest part, gradually widening The extreme narrowness and crookedness of the channel militate against its value as a harbor for naval operations on a large scale, while they add to the ease with which it may be defended from attack. It is safe to say that the port may easily be made impregnable from the sea side.

Between Santiago de Cuba and Cape Cruz there are several points at which anchorage may be had, though of small area. At *Ensenada de Mora*, as yet unexplored, a survey may develop a safe and commodious harbor.

The entire unreliability of the charts of that portion of the coast extending from Cape Cruz 150 miles N.W., and the vagueness of the sailing directions for these waters demand a resurvey

of this region, before its possibilities can in any way be predicated as to harbors for operation or refuge.

Port Xagua or *Cienfuegos* (see description, "Sailing Directions, Caribbean Sea, etc.," No. 86, Vol. I) presents many features to commend it to the attention as a safe and excellent harbor when once gained. Though having a larger area of anchorage ground than Santiago de Cuba, its long and narrow entrance channel places it in the same category, for naval purposes, as that port. It is, moreover, less easily defended by mines.

From Cienfuegos to the westward, there appears to be no deep-draft harbor, though there are many safe and extensive anchorages for light-draft vessels.

From the foregoing general survey of ports, it will be seen that Cuba, while possessing many harbors adapted to commercial use, has few that show in full the requirements demanded for a naval base. These requisites are: a sufficiently wide entrance to permit exit in strong force; a deep and protected anchorage of large extent; a capacity for ready and complete defense; and above all, a geographical location suited to strategic demands. There are several that possess two elements in an eminent degree, and but two that may be considered as presenting the four requisites combined—Nipe and Guantanamo. Unfortunately, these two ports are both situated in the eastern end of the island, about 90 and 70 miles respectively from Cape Maysi. Of the two, however, Guantanamo is by far the better, and is the one that should be selected for occupation and defense by our Government, while Nipe should be so defended as to preclude the possibility of its falling into the hands of an adversary.

Of the more western ports on the north coast, it is probable that Havana, at the moment, possesses the advantage over all others, owing to the state of its defenses, though it has very serious defects. Should a resurvey of Port Cabanas demonstrate a deep-water channel, that port would seem to afford more of the natural requisites for a fleet rendezvous, besides being better situated than Havana. The possibility of a good harbor inside the reef to the north of Cape San Antonio should not be lost sight of, since such a port would have an ideal geographical position.

The port of Cienfuegos has such excellent and secure anchorage of large extent, is so readily defended, that, though

badly located strategically, except as to its position in reference to the proposed isthmian canal, its tactical merits cannot be overlooked. The channel, though narrow and tortuous, is reported as not difficult. This port should be held in sufficient force to make secure its possession to our Government.

The question of the supplies to be obtained at the various ports is one of little moment in modern warfare. It is better to consider that a fleet and occupying army must depend on their own supply-ships for all the necessaries of life.

It seems self-evident that any attack made on the United States by a European State in the future, will have for its objective our possessions and dependencies in the West Indies, and it is in those waters that the Navy will be called upon to defend the national rights and honor. It is well, therefore, to take stock of the facilities afforded by nature for the strengthening of our cause, and to make such additional improvements, in the way of fortifications, as may render such natural strongholds most secure.

With the feeble and impotent island of San Domingo lying directly between Cuba and Puerto Rico, we may confidently predict that the base for any operations against these two islands will be there established. A trumped-up claim unsatisfied can be made the pretext for an armed occupancy of any port in that island. International law and courtesy would be cast to the winds—as it has been in China—and the right of might established. It therefore behooves the United States to look the conditions square in the face and to determine to what extent preparations are to be made to meet the inevitable. With every nation in Europe suffering with a grievous attack of land famine, are not the acts of their legislatures, in increasing so enormously their navies, handwritings on the wall, needing no Daniel to interpret, foretelling that in the near future these nations will brave the woes dimly defined by the *Monroe Doctrine*, and wrestle for a slice of the rich lands of our hemisphere?

Wherever internal troubles exist and law and order are at a discount, there is a locality at which foreign intervention may be expected. When the hour comes in which we are hopelessly outclassed on the sea—and that time is approaching with rapid strides—then, we may be fully assured, will strike the hour of our country's humiliation. Vain will it be to call upon the

Shade of Monroe to protect his own. That bugaboo to foreigners will be laid beyond resurrection and we shall find that blood and treasure untold will be necessary to repair the breach in our outer walls. With Guantanamo, Nipe, Cienfuegos and Havana held in a firm grip and properly managed, we have at any moment bases ready made from which to issue in defense of national honor.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ON THE EXAMINATION OF NAVY-YARD APPRENTICES.

By HENRY G. BEYER, Surgeon U. S. N.

The government in providing an examination for applicants for positions as apprentices in the different shops of navy yards secures thereby several important objects and advantages. The mental part of such an examination, when conscientiously and properly conducted, will insure a higher degree of intelligence among the workingmen of the future and, consequently, a better quality of work in all the different departments at navy yards. The physical examination, as a means of selecting none but physically fit subjects for these positions, contributes, moreover, towards increasing very materially the value in time and money which the government invests in these boys by teaching them a trade, on account of the fact that the average life of apprentices thus selected will naturally be longer than that of the physically unfit. The method that has recently been followed out for the examination of these apprentices at the Boston Navy Yard, in accordance with Navy-yard Order No. 14, Revised, is so well adapted to the purpose and, at the same time, so far in advance of the older methods, that a brief description of it seems rather desirable, especially so as its general adoption throughout the service would seem to be as advisable as it is desirable.

Navy-yard Order No. 14, Revised, requires that each applicant shall be marked for his physical examination. As regards the physical part of an examination, there had never been any system in vogue either in the Navy or elsewhere, to my knowledge at least, by means of which a candidate was given a definite

mark, expressed by a number which should count in the sum total of his entire examination, and thus be made the means of materially assisting him to get or preventing him from getting, as the case might be, the coveted position. A candidate for any position in the Navy, including that of cadet, is found either fit or unfit, is either accepted or rejected accordingly, on physical examination, without any fixed or well-defined system of marking. In the case of an examination being required, the marks obtained in the mental were the only ones that were counted. Physical excellence being so obvious a factor in the general make-up of the *personnel* of a service like the Navy, it had long since seemed to me desirable to establish some standard which should be absolutely accurate as well as calculated to give a boy credit for the physical advantages or disadvantages which he possessed in such a manner as to permanently influence his career and without doing him the least injustice. Knowing, moreover, that his physique would count in the final examination, it would serve as the very best stimulus for him to improve it whenever opportunity was favorable. This was undoubtedly the intention of the order under which Examining Boards of Navy Yards were obliged to do their work, although the more general applicability of the same principle must be clear to every one acquainted with the needs of the service. After considerable thought on the matter, it occurred to me that the best method of attaining this end was to make use of the percentile grade system and the normal growth and development tables published in the proceedings of the U. S. Naval Institute No. 74, and give each boy the proper physical percentage which, by nature and according to his age, belonged to him. One of these tables, No. XIX, for the sake of convenience is here reproduced. duced.

After this manner, a boy becomes his own physical record and takes his relative percentage position and mark without there being the slightest chance for the examiner to do him the least injustice or to favor him in any way. No mental examination can compare with it as regards accuracy of results and fairness to the individual. If, for example, the boy is superior in physique, he has advantages which it is useless for anyone, not up to his standard, to dispute him, and he should receive the necessary credit for them; if he is inferior, the boy can blame

no one, except perhaps himself, for not having exercised proper care in the selection of his ancestors. No argument can change his record or mark; his own exertions alone might improve it.

Method.—The method is simple and may be briefly described as follows: A boy's age is calculated from the nearest birthday and found to be fifteen; he is now measured in the usual way and his height standing is recorded as 64.3 inches. What is his mark or height? Table XIX, finding the line of the height opposite the fifteen-year old boys, we follow it until we come to 64.29, which is the nearest to his recorded height, and the percentage number above this value will be found to be 50, which is the mark the boy is entitled to receive for his

TABLE XIX.—HEIGHTS AND PERCENTAGES.*

Age at nearest birthday.	Number of observations.	VALUES IN INCHES AT THE FOLLOWING PERCENTILE GRADES.										
		5.	10.	20.	30.	40.	50.	60.	70.	80.	90.	95.
15	181	59.507	60.310	61.563	62.553	63.457	64.290	64.855	65.764	66.653	67.717	69.290
16	395	61.750	62.549	63.714	64.580	65.250	65.805	66.455	67.200	68.020	69.000	70.406
17	722	63.130	64.217	65.165	65.853	66.434	67.000	67.626	68.317	69.100	70.320	71.320
18	841	64.193	65.000	65.886	66.483	67.044	67.633	68.251	68.920	69.665	70.520	71.530
19	750	64.680	65.391	66.250	66.844	67.424	67.651	68.600	69.243	69.786	71.000	71.880
20	645	64.962	65.543	66.413	67.094	67.675	68.252	68.810	69.477	70.253	71.280	72.120
21	496	64.970	65.620	66.433	67.054	67.667	68.215	68.852	69.483	70.180	71.120	72.000
22	328	64.945	65.831	66.580	67.200	67.762	68.352	68.960	69.927	70.632	71.543	72.258
23	232	65.287	65.800	66.580	67.300	68.010	68.522	69.030	69.625	70.307	71.240	72.000

* See Beyer—U. S. Naval Inst. Proc., No. 74.

height; he is an average boy for his age. This simple process is applied in finding the percentages of any other dimension that it is desired to include in the examination by referring to the respective tables of these different dimensions. Height, weight, chest-circumference being the leading dimensions, these were the only ones made use of in the present instance. The percentage values ascertained and calculated after this manner are now added together and averaged; their average constitutes the boy's mark for his physical examination.

There is, however, one item which is not to be found in the percentile grade tables which must be included in the result. This item we have termed "general health," and its value is

ascertained through an examination which is purely medical in character. The chief factor in this is a good heart and a good pair of lungs; a secondary factor is whether a boy approaches or not the percentile grade into which he belongs in regard to the greatest number and the most important portion of all his dimensions. A boy, for example, whose height puts him into the 75th percentile grade, but whose chest-circumference places him into the 25th percentile grade, would not be entitled to get the mathematical average of these two numbers for general health but would receive about 35 instead of 50.

In accordance with the above-described method, eighty-five boys of an average age of sixteen years were examined in the Boston Navy Yard about three months ago. Seventy of these boys were accepted (82 per cent) and fifteen rejected (18 per cent) by the physical examination alone. The adjoining Table I has been arranged to show the relations existing between the accepted and the rejected boys and also that which both these bear to the total number examined.

TABLE I.—AVERAGES.

AVERAGES.	*a.* THE PERCENTILE GRADES.						*b.* IN ACTUAL MEASUREMENT.					
	Age.	Height.	Weight.	Chest Circum.	General Health.	Average.	Age.	Height.	Weight.	Chest Circum.	General Health.	Average.
All 85 boys examined..	16	34	38	45	40	39	16	64.9″	112 lbs.	30.8″	40	39
The 70 boys accepted ..	16	34	40	48	42	41	16	64.9″	114 lbs.	31.″	42	41
The 15 boys rejected...	16	32	25	26	20	26	16	64.7″	106 lbs.	29.7″	20	26
Differences .	0	2	15	22	22	15	0	.2″	8 lbs.	1.3″	22	15

In explanation of the large percentage of boys that were accepted (82 per cent) it must be added that the understanding of the members of the board that the mere fact of a boy's being small in stature and light of weight should in no instance be regarded as a sufficient cause in itself alone for his rejection, inasmuch as such a boy might still be one of more than average

health. In this respect it was not considered necessary to exact from navy-yard apprentices the rigid standard for strength, power and endurance that was usually required from apprentices intended for the regular Navy. Nor were color-blindness and defective vision, unless the latter was very bad, made a leading cause for rejecting a boy.

A comparison of the averages received by the accepted boys and the rejected ones, seen in Table I, shows the accepted ones to be superior in all respects to the rejected ones, but more especially so in respect to weight, chest-circumference and general health, notwithstanding the fact, which was mentioned before, that a small boy and a light boy was not necessarily rejected on account of his being light and small; consequently, many of just such boys are included in the averages obtained from the accepted ones.

The mental examination was to consist of both written and oral examinations, and include spelling and simple arithmetic, also decimals and the rule of three, 100 being considered perfect. All the boys had left school two years previously to this and engaged in various occupations since that time; they all belonged to the same class of people and lived in the closest vicinity of Charlestown.

The adjoining Table II is intended to show how the results of the combined examinations were finally calculated and to still further illustrate the simplicity of the method according to which a boy received his final mark.

TABLE II.

William B.	Mark.		Multiple.		Total.
Physical	50	×	3	=	150
Mental.....	75	×	5	=	375
Oral.....	83	×	2	=	166
Total					691

Out of the seventy boys who had passed their physical examination only sixty-two presented themselves for the mental examination. One, however, being a colored boy, was omitted from my list on account of its being desirable to have the material homogeneous for the purpose of further comparison and this leaves sixty-one to be studied.

Both examinations having been completed in accordance with

the above-described methods, all the sixty-one boys were arranged in a table in the order of their relative merit so that the boy having received the highest mark stood first on the list, while the boy having received the lowest number, stood at the bottom of this list. Dividing, now, the total number of sixty-one by ten, and finding the average of each section of ten, we would, of course, expect to find that the first ten presented the highest average, while the last ten would show the lowest average, at least so far as regards the column of totals.

This same result need not necessarily be expected from similar averages obtained from the column of physical marks. If, however, the physical composition of a boy has indeed any relation to his mental qualifications; if, in other words, there is such a thing as a psycho-physical relation in man, then we would expect to find, on comparing all these averages, that they all equally show a gradual decrease in values from first to last, and this, indeed, they do, as shown in Table III.

TABLE III.—TABULATED RESULT OF AVERAGES.

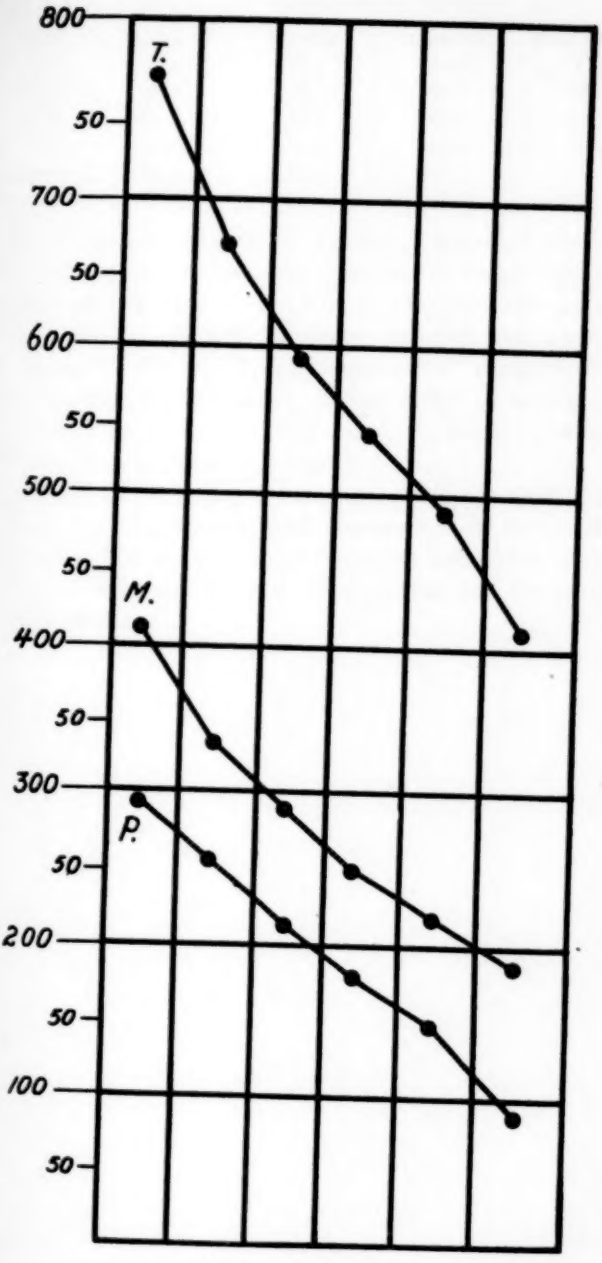
Ten.	Physical.	Mental.	Total.
1	296	415	770
2	263	332	667
3	215	297	598
4	185	255	541
5	157	222	496
6	95	191	404

The oral was not included in this table because not amounting in value to a real examination.

The adjoining curves constructed from the table show the relation existing between the averages in a still clearer light (see Plate I).

In the marks from which the physical curve was constructed are contained increments of height, weight, chest-circumference and general health. It was, therefore, of some interest and importance to ascertain whether all these four items contributed alike or whether one or the other of them contributed more than any other toward the general result. With this end in view, each of these four items was arranged in the same order as were the totals with results seen in Table IV.

PLATE I.



P = physical. M = mental. T = total.

TABLE IV.—AVERAGES IN PER CENT.

Ten.	Height.	Weight.	Chest Circ.	Gen. Health.
1	55.4	64.4	64.2	53.0
2	37.4	60.4	61.5	53.0
3	38.8	39.4	49.6	45.0
4	35.5	29.2	35.8	36.0
5	27.3	31.3	41.1	37.0
6	10.0	14.0	26.0	28.0

Table IV shows there is a difference between the first ten and the last ten or eleven of 45 per cent in height, 50 per cent in weight, 38 per cent in chest-circumference and 25 per cent in general health. It will, therefore, be seen that all the items which entered the total physical mark contributed in a measure to the general result, in the order in which they are tabulated and in a manner that seems to leave no doubt with regard to their meaning and significance.

In addition to its being a new and most practical method of examining, an examination and comparison of its results have, unexpectedly, led us to discover a most important and significant relation existing between the physique and the mental performances of man.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A PROPOSED NEW METHOD OF SCORING TARGET PRACTICE IN THE NAVY.

By LIEUTENANT J. B. BLISH, U. S. Navy.

This method is based upon the *angle of error*, which is defined as follows:

Imagining—(1) a straight line passing through the rear sight of the piece and the center of the target.

(2) a vertical plane through the target at right angles to the vertical plane containing the line (1).

(3) a straight line passing through the rear sight and the point where the projectile pierces the vertical plane (2), then:

The *angle of error* is the angle at the rear sight between the lines (1) and (3).

Its tangent is the ratio of the lineal error, measured on the vertical plane (2) to the range.

Being small, angles of error may be taken as proportional to their tangents.

The minute of arc is taken as the unit angle of error. Its tangent is $\frac{3}{10000}$.

DETERMINATION OF THE ANGLE OF ERROR.

1. *By estimation.*—In subcaliber practice usually a mark floating on the water is used as a target, and the splash of each bullet shows how near it passed. In judging the distance of this splash from the target, the mind unconsciously estimates the angle of error and, knowing the range, arrives at the lineal error. It is easier, after short practice, to estimate the angle of error than to

estimate the lineal error, since the range does not have to be considered. It is also easier to estimate separately the lateral angle of error and the vertical angle of error. The whole angle of error can then be taken from the accompanying table.

These angles are estimated from the center of the splash to the center of the target, so that the size of the target is eliminated.

To assist the judgment in estimating these small angles, use can be made of the ordinary T-square, after calculating the angles subtended by the wires themselves.

In one of these instruments the distance from the eye piece to the zero wire was 34⅞ inches.

The zero wire was No. 17 B. W. G. and its thickness 0.058 inches.

This wire subtends an angle of 5.′76 at the eye piece.

The next wire on either side of the zero wire was No. 22 B. W. G. and was 0.028 inches thick.

Each of these wires subtends an angle of 2.′78.

Occasional reference to this instrument will be of assistance in estimating the small angles of error.

It may be noted that the smaller the angle, the closer its value can be estimated: the better the shooting, the more exact the score.

An instrument whereby these small angles could be accurately measured would be of great value, but with care and practice a fair and even degree of accuracy can be arrived at by estimation.

These angles are recorded in minutes (and decimals) of arc, and the corresponding angle of error, taken from the table, is recorded as the score of that shot.

A sample page of a convenient score-book is shown opposite page 358. It is on cross-section paper of ten lines to the inch.

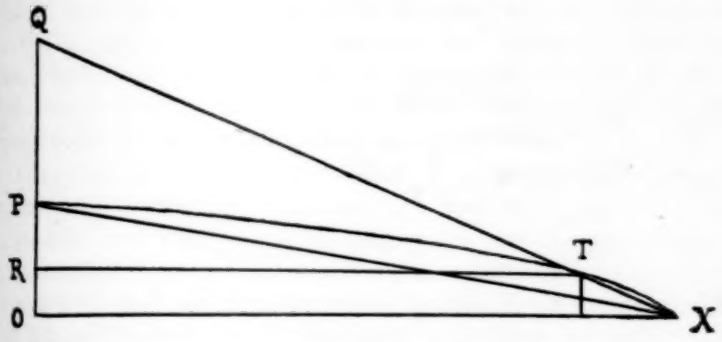
The error in estimating the lateral angle, due to the eye of the observer not being at the exact intersection of the lines (1) and (3), varies inversely as the range, and is practically eliminated by the observer standing close to the piece.

The error in estimating the vertical angle, due to the curve of the trajectory, increases with the range, but can be almost entirely eliminated by stationing that observer at a certain height above the piece depending upon (1) the curve of the trajectory for the

range of the target, (2) the height of the piece above the water and (3) the height of the target above the water.

The height of this observer should be such that he sees the target and the splash of a bullet that has passed through the target in line.

It may be calculated approximately as follows:



Let Q represent the observer, P the piece, T the target, X the splash, OX the surface of the water, and PTX the trajectory.

RT = the range.

PR = the height of the gun above the target.

The angle QTP is approximately equal to the *angle of fall* of the projectile for the range RT, and is taken from the range table or measured from the drawing of the trajectory.

The angle PTR is found by

$$\tan PTR = \frac{PR = \text{height of gun above target}}{RT \quad \text{Range}}.$$

(1) $$QTR = QTP + PTR.$$

(2) $$RQ = RT \tan QTR.$$

(3) $$PQ = RQ - RP.$$

Examples.

U. S. S. New York.

After 8-inch turret gun firing 6 mm. subcaliber.

Height of gun above the water, 25 feet, 25

Height of flag on target above the water, 2 feet, 2

PR = 23

Range = 600 yards = 1800 feet.

$$\text{Tan } PTR = \frac{23}{1800}.$$

$$\text{Tan } 1' = \frac{3}{10000}.$$

$$PTR = \frac{23}{1800} \div \frac{3}{10000} = 42'.6.$$

$PTR = 42'.6.$

$QTP = 17'.4$ assumed for 6 mm. at 600 yards.

$QTR = 60'.$

$$\text{Tan } QTR = \frac{180}{10000} = \frac{18}{1000}.$$

$RT = 1800.$

$$RQ = 1800 \times \frac{18}{1000} = \frac{324}{10} = 32.4 \text{ feet.}$$

$PR =$ 23.0

$PQ =$ 9.4 feet.

Which is about the height, above the center of the bore, of the eye of an observer standing on top of the turret, so that the vertical angle of error as seen by him is not distorted.

U. S. S. Amphitrite.

1-pdr. field mount firing drill cartridge .45 subcaliber.

Height of gun above water, 7 feet.

Height of flag of target above water, 2 feet.

$PR =$ 5 feet.

Range = 300 yards, = 900 feet.

$$\text{Tan } PTR = \frac{5}{900} = \frac{555}{100000}$$

$PTR = 18'.5.$

$QTP = \frac{450}{} = 7°\ 30'$ assumed for short 1-pdr. drill cartridge, caliber .45.

$QTR = 468'.5$

$$\text{Tan } QTP = \frac{468.5 \times 3}{10000} = \frac{14055}{100000}$$

$RT = 900$

$$RQ = \frac{14055}{100000} \times 900 = \frac{126495}{1000} = 127 \text{ feet.}$$

The observer of the vertical angle of error should be 127 feet above the water in order to correctly observe that angle.

To Determine the Angle of Error by Measurement.

In record great-gun practice the lateral angle of error is measured on board the ship by the T-square. Usually it is not recorded closer than one-quarter of a degree, but closer approximation is possible (especially for good shooting) and more accurate work would be induced by habitually recording this angle in minutes of arc.

The horizontal fall of shots is plotted from the angles observed in the boats and, by means of the Plotting Tables, the range and bearing of the target being known, the vertical (lineal) error is found. This vertical lineal error divided by the range is the tangent of the vertical angle of error.

Thus this practice can be recorded in the same manner as subcaliber practice and in the same score-book.

In rifle and pistol practice with paper or painted targets, cross-section lines can be drawn on the targets before using and the lateral error can be noted by counting the spaces right or left from the center of the target to the bullet mark, and the vertical angle by the number of spaces above or below the center.

Knowing the width of the cross-section spaces (say 2 or 4 inches) and the range, the lateral and the vertical angles of error can be calculated and recorded, and the corresponding angle of error is found from the table.

Cross-section paper (or better yet cross-section sheeting) about a yard wide, could be purchased in rolls and cut up into targets as required; the mark or bull's eye could be painted on of such size as to best suit the arm, range, light, etc.

In *aiming drill*, after a triangle of shots is made, the real line of sight can be determined geometrically (by finding the intersection of the medial lines of the triangle) or it can be located by the instructor by sighting.

Having located the point of impact of this line, the lineal error of each shot can be found by measuring its distance from this impact. Dividing this error by the range gives the tangent of the angle of error. Note that in this case the range is measured from the target to the rear sight or to the cross-wires of a telescopic sight.

If cross-section paper is used for marking the impacts, the lateral and vertical errors are read off directly and their angles are calculated and recorded.

Torpedo practice, in which the angle of error is lateral only, can be readily scored by this method.

In each kind of practice every shot is scored by its angle of error; each string of shots by the average of the angles of error.

Practice with different classes of guns can be readily combined so that a single angle represents an absolute measure of marksmanship. Furthermore, firing at different ranges and under different conditions of roll, smoke, wind, speed of target, speed of ship, etc., can all be reduced to a common standard. This is done by a system of multiples not unlike that in use at the Naval Academy for determining class standing. To do this each class of guns, each range, and each of the various conditions under which the firings take place are assigned multiples. The angles of error are multiplied by these multiples and the sum of the products is divided by the sum of the multiples used; the resultant angle is the corrected score.

The following multiples are assigned tentatively:

GUN MULTIPLES.

Class.	*Gun.*	*Multiple.*
a	Pistol,	1
b	6 mm., on shore,	3
c	6 mm., afloat,	4
d	Boat gun,	2
e	Secondary battery,	5
f	Main battery, new R. F. mounts,	7
g	Main battery,	8
h	Main battery, turrets,	10

EXAMPLE.

William Jones (Cox.):—

Gun.	*Score.*	*Multiple.*	*Product.*		*Final.*
a	3.0	1	3.0		
c	2.5	4	10.0		
e	3.0	5	15.0		
g	5.0	8	40.0		
		18	68.0	=	3.78

John Brown (G. C., 1 Cl.):—

b	2.0	3	6.0	
d	2.5	2	5.0	
f	4.0	7	28.0	
h	10.0	10	100.0	
		22	139.0	= 6.32

RANGE MULTIPLES.

Range.	*Multiple.*
Close range,	3
Fighting range,	4
Long range,	5

EXAMPLE.

William Jones (Cox.):— Fired two strings of shots from a 6 mm.

	Score.	*Range.*		*Multiple.*	*Product.*	*Final.*
1st string,	2.8	Close,	(100 yds.)	2	5.6	
2d string,	3.5	Fighting,	(600 yds.)	4	14.0	
				6	19.6	= 3.27

TARGET MULTIPLES.

Class.	*Target.*	*Ship.*	*Multiples.*
a	Fixed.	At anchor.	1
b	Towed astern.	Under way.	3
c	Towed by steamer.	At anchor.	4
d	Towed by another ship.	Under way.	6

CONDITION MULTIPLES.

Class.	*Wind, smoke, roll, light, etc.*	*Multiples.*
a	Good.	1
b	Fair.	2
c	Bad.	4

These data (and others, if desired) are noted in the score-book and can be made use of at any time to compare different scores.

Time allowance multiples for each class of gun can also be assigned.

There seems to be no simple solution to the problems of indicating in the score (1) the number of shots from which it is made up, and (2) the number of different classes of guns that were fired in making up a man's score.

The question of assigning different multiples to the horizontal and to the vertical angles in computing the total angle of error, instead of combining them with equal weights as is done in the table, is one of such importance that it would seem best to leave

it open for the present. To the end of arriving at the best solution of that problem, it would be well always to record both of these angles and preserve the records for study.

It is believed that this method of scoring presents the following advantages :—

(1) It is simple and easily understood.

(2) It measures skill in marksmanship.

(3) It measures the improvement due to instruction, practice, desire to improve, etc.

(4) The skill of two or more men, guns' crews, divisions, ships or squadrons, can be compared for the purpose of fostering the spirit of competition.

(5) Scores can be compared to a standard for awarding prizes, etc.

(6) Scores with different arms can be compared.

(7) It furnishes data for representation and study of the efficiency of gun fire.

Recapitulation.

By this method, each shot is scored by a number representing the angle of error expressed in minutes of arc.

The score for a string of shots is the average of the separate shots of the string.

The score for a gun's crew, division, ship or squadron is likewise the average of the individual scores.

Perfection is represented by zero.

Some difficulty may be encountered in teaching some men that good shooting is represented by a small score, but a short dissertation on the subject, accompanied by practical illustration at aiming drill, ought soon to overcome this.

Cross-section paper or small slates with cross-section lines scratched on them could be furnished the men on which to plot their scores; each space representing one minute of angle of error.

To combine scores made under different conditions, at different ranges, with different classes of guns, etc., and to take account of time allowances, a system of multiples is made use of, but the corrected score always remains an angle (expressed in minutes of arc).

In conclusion, the following suggestions regarding subcaliber practice (for the originality of which no claim is made) are offered.

(1) Since the Army caliber is to replace the Navy 6 mm., that the 6 mm. rifle be issued for subcaliber practice.

Among the advantages of this are:

Its high velocity permits the use of the full charge side of the sight bar, without allowance (or nearly so).

The absence of smoke, dirt, and the annoying report of black powder cartridges.

The bullet is not apt to ricochet on water (I have never known an instance.)

The splash is almost, if not as plainly seen as that of the .45 caliber.

Owing to its flat trajectory, the splash of the bullet as seen by the man who fired it marks the angle of error with very little distortion.

(2) That this rifle be fitted to all guns of the secondary battery (including boat guns) and main battery. In the former the rifle could well be fitted outside of the barrel; its easy recoil not necessitating very strong fittings. All of these fittings can be readily made on board ship until the regular ones are issued.

(3) That subcaliber practice be made a daily routine whenever possible. At sea in company with other vessels, targets can be towed by each ship for another to fire at. A single vessel can practice at a target towing astern. In port, where the great range of this gun might render this practice dangerous, a certain number of these rifles might have the barrels sawed off for the purpose of reducing the initial velocity of the bullets. While this would sacrifice the advantages of a flat trajectory, the other good points of the rifle for this purpose would be retained.

(4) That standard score-books be issued; the leaves to be cross-section paper (ruled on both sides) and replaced when necessary from paper kept in store.

DISCUSSION.

Lieutenant J. H. GLENNON, U. S. N.—In connection with this system of recording target practice, the use of a telescope or tube with a number of cross wires seems to recommend itself. The center pair of wires, or the

center of the field of view of telescope or tube, should of course be plainly marked. An observer with the telescope or tube notes the intersection of wires on which the shot hits, the center being on the target. If now a similar telescope or tube is used as a gun-sight, and if the observer is in the line of fall of the projectile, as proposed by Lieutenant Blish, the intersection as seen by the observer may be used in the gun-sight in place of the center, and the shots should go true. For example, the observer sings out 2 right 3 down, referring to the divisions of his instrument. The gun-pointer brings 2 right 3 down on the target for the next shot. Succeeding points for the target should of course be placed relatively in each case to the one preceding. It would be necessary to have one set of wires horizontal or nearly so in the observer's instrument, and therefore he should occasionally bring it on the horizon for verification.

This method conforms to the marksman's rule, after getting a shot on a target, of changing his point of aim in place of changing the sight. In ordinary direct fire it is not necessary for the observer to get exactly in the line of fall. It is more important generally that he be directly above the gun; this will enable the correction for speed, wind, etc., to be made.

BROWN, JOHN. (G.C. 1CL.)

No.	TIME	HORIZ.	VERT.	SCORE	6 IN TURRET
1		25	10	27	6 M/M GUN
2		5	10	11	
3		0	0	0	6, 500 YDS.
4		5	5	7	
5	10 5	0	5	5	TARGET C
6	10 5	35	30	50	
	21	7	6	100	CONDITION A.

SMITH, G. W. (MESS ATT.)

No.	TIME	HORIZ.	VERT.	SCORE	REVOLVER
1		10	0	10	300 YDS.
		8	4	9	
		0	13	13	TARGET A
		12	5	12	CONDITION A
		9	0	8	
5	25	20	5	21	TRAIN STA.
6	25	55	225	68	NEWPORT
		76	82	178	173

DILLON, JOHN (LDS.)

No.	RIGHT	LEFT	SHORT	OVER	SCORE
1	15		35		38
2		5		45	45
3		0	15		15
	15	5	50	45	98
	15	3	35	45	327

AIMING DRILL 4 IN R.F.

37 FT CONDITION A.

LIEUT. JONES.

No.	RIGHT	LEFT	SCORE
1	10		10
2		25	25
3			25
	10	25	175

18 IN WHITEHEAD
OBAY
950 YDS.
TARGET C
SPEED 11.5
CONDITION B

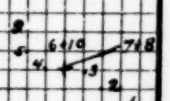
OFF BLOCK 10. JULY 10 1900.

NAVAL CADET BANKS.

No.	TIME	RIGHT	LEFT	SHORT	OVER	SCORE
1	0 0	2		1		22
2		1		5		11
3		5		0		5
4			5	0		5
5	7 5		1		5	11
6	1 5 0		5		5	7
7			0		0	0
8			0		0	0
9			1	1		14
G	2 5 0		5		5	7
H	2 5 0	6 5	3 5	1 3	2 5	82
	3 5	12	6	4	4	082

6 M/M 100 YDS.

STANDING.
CALM.
SHEETING TARGET.
CONDITION A
KEY WEST
MARCH 9.

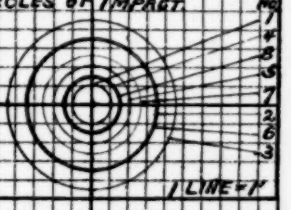


4 INCH 6 PDR. CREW.

No.	NAME	RATE	CLASS	SCORE
1	BROWN, WM	CAP.		100
2	JONES, T.	SEA.		332
3	SMITH, R.	LAS.		450
4	JOHNSON, C.B.	APP.	1 CL.	150
5	ALLEN, M.	APP.	2 CL.	200
6	ANDERSON, N	MAC.	3 CL.	345
7	LARSEN, O	O.S.		258
8	KENNEY, J	BOY		154
				1980
				249

AIMING DRILL
AT SEA
CONDITION A

CIRCLES OF IMPACT.

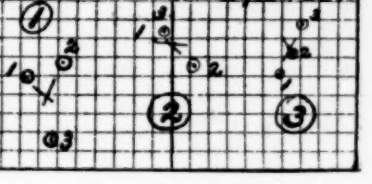


THOMPSON, T. (LDS.)

No.	SCORE	SCORE	SCORE
1	13	13	13
2	16	16	3
3	23	13	16
4	30	44	32
	79	107	102
	107		
	107		
	47		
	78		

AIMING
6 M/M
AT ANCHOR
CONDITION B.

THOMPSON'S TRIANGLES AT 27.8 FEET.



	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10
0.5 ..	0.7	1.1	1.6	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10
1.0 ..	1.1	1.4	1.8	2.2	2.7	3.2	3.7	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.5	10
1.5 ..	1.6	1.8	2.1	2.5	2.9	3.3	3.8	4.3	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.6	9.1	9.6	10
2.0 ..	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	4.9	5.4	5.9	6.3	6.8	7.3	7.8	8.2	8.7	9.2	9.7	10
2.5 ..	2.5	2.7	2.9	3.2	3.5	3.9	4.3	4.7	5.1	5.6	6.0	6.5	7.0	7.4	7.9	8.4	8.9	9.4	9.8	10
3.0 ..	3.0	3.2	3.3	3.6	3.9	4.1	4.6	5.0	5.4	5.8	6.3	6.7	7.2	7.6	8.1	8.6	9.0	9.5	10	10
3.5 ..	3.5	3.7	3.8	4.0	4.3	4.6	4.9	5.3	5.7	6.1	6.6	6.9	7.4	7.9	8.3	8.8	9.2	9.7	10	11
4.0 ..	4.0	4.1	4.3	4.5	4.7	5.0	5.3	5.7	6.1	6.4	6.8	7.2	7.7	8.1	8.5	9.0	9.4	9.8	10	11
4.5 ..	4.5	4.6	4.7	4.9	5.1	5.4	5.7	6.1	6.4	6.7	7.1	7.5	7.9	8.3	8.7	9.2	9.5	10	10	11
5.0 ..	5.0	5.1	5.2	5.4	5.6	5.8	6.1	6.4	6.7	7.1	7.4	7.8	8.2	8.6	9.0	9.4	10	10	11	11
5.5 ..	5.5	5.6	5.7	5.9	6.0	6.3	6.6	6.8	7.1	7.4	7.8	8.2	8.5	8.9	9.3	9.7	10	11	11	11
6.0 ..	6.0	6.1	6.2	6.3	6.5	6.7	6.9	7.2	7.5	7.8	8.2	8.5	8.8	9.2	9.6	10	10	11	11	12
6.5 ..	6.5	6.6	6.7	6.8	7.0	7.2	7.4	7.7	7.9	8.2	8.5	8.8	9.2	9.6	9.9	10	11	11	11	12
7.0 ..	7.0	7.1	7.2	7.3	7.4	7.6	7.9	8.1	8.3	8.6	8.9	9.3	9.6	9.9	10	11	11	11	12	12
7.5 ..	7.5	7.6	7.7	7.8	7.9	8.1	8.3	8.5	8.7	9.0	9.3	9.6	9.9	10	11	11	11	12	12	12
8.0 ..	8.0	8.1	8.1	8.2	8.4	8.6	8 8	9.0	9.2	9.4	9.7	10	10	11	11	11	12	12	12	13
8.5 ..	8.5	8.6	8.6	8.7	8.9	9.0	9.2	9.4	9.5	10	10	10	11	11	11	12	12	12	13	13
9.0 ..	9.0	9.1	9.1	9.2	9.4	9.5	9.7	9.8	10	10	11	11	11	11	12	12	12	13	13	13
9.5 ..	9.5	9.5	9.6	9.7	9.8	10	10	10	10	11	11	11	11	12	12	12	13	13	13	14
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9.5	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	30	60
9.5	10																			
9.5	10																			
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9.7	10																			
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39	39	40	40	40	40	41	41	41	42	42	43	43	44	45	45	45	45	46	47	71
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46	46	46	46	47	47	47	48	48	48	49	49	50	50	50	51	51	52	53	54	75
51	51	51	51	52	52	52	52	53	53	53	54	54	55	55	56	56	57	58	58	78
61	61	61	61	61	62	62	62	62	63	63	63	64	64	64	65	65	65	66	67	85
91	91	91	91	91	91	91	91	92	92	92	92	92	93	93	93	93	94	94	95	110

DISCUSSION.

TORPEDO CRAFT: TYPES AND EMPLOYMENT.

(Discussion continued from No. 93.)

Lieutenant R. H. JACKSON, U. S. N.—In replying to the discussions upon this article, I will briefly note the opinions which are diverse.

Commander Drake advocates a destroyer between 1000 and 2000 tons displacement, 25 knots, armed with a powerful battery of light guns; he also places torpedoes on this vessel. She should also have a large coal capacity. We have now an excellent scout and despatch vessel; but the need of her torpedo armament has now disappeared, as she is debarred by her size from attempting a surprise attack as a torpedo-boat.

Lieutenant R. C. Smith advocates a somewhat similar vessel with a small battery and no torpedoes, and calls her a despatch-boat; he creates this type to prevent the misuse of the torpedo-destroyer and boat. The Mayflower was the nearest vessel to this type during the war, but did not possess the speed. She was, however, an exceedingly useful vessel.

Although a machine gun was advocated for the Giom type only, it could be employed with advantage on the other types of boats against exposed crews of other boats or troops ashore.

I do not think the practical utility of a low-power shell gun advocated by Commander Kimball would be demonstrated under service conditions.

Lieutenant Chandler's armament of two 14-pdrs. and six 6-pdrs. automatic would make a very heavy battery. I do not think the after 14-pdr. an essential at any rate, a bow-chaser being sufficient.

An error is claimed in the present number of the Proceedings, referring to the performance of the Dupont. My statement of her mileage was obtained from one of her officers who had worked it out. I find that it should have been approximately 12,000 miles, if counted from her commission till her date of sailing north after the war.

As I am heartily in favor of this type, I take pleasure in so improving her record.

The steering engine of torpedo-boats of all types should be placed in the engine-room. They have been so placed in a few boats, and in many vessels of greater displacement. The efficiency of the engine and the comfort of the crew are increased, and the engine is less liable to be disabled by a shot.

Lieutenant SPENCER S. WOOD, U. S. N.—I regret extremely that this paper did not reach me until March 17th, too late to present my remarks upon it, and that I am too busy even now to give it the attention which it merits. The subject of torpedo craft and their uses is very near my heart, and I would gladly go deeper into the discussion had I the time, but I cannot let the statements made on page 11, at the bottom, in regard to the performance of the Dupont go unchallenged. I fear Mr. Jackson

has not looked into the facts of the case closely enough or he would not have rendered himself liable to such errors.

The Dupont accompanied the fleet when it sailed to Havana on April 22, and the following day, when on the blockade off Matanzas, remaining there until the 27th, when she returned to Key West for coal, leaving there at 8 A. M. of the 29th to resume blockading station. On May 7 again returned to Key West for coal, where she was detained until the 16th for despatch duty, but on that day she was sent to meet the fleet in the Old Bahama Channel. After delivering the despatches, she returned to Key West, arriving at 5 P. M. on May 18. On the 20th, at 8 A. M., the Dupont left Key West to carry despatches for the Flying Squadron off Cienfuegos. She did not accompany "a squadron to Cienfuegos," but made the run alone and unaided. She remained with that squadron on the blockade and patrol duty until May 24, when she was sent to Key West with despatches. She then had to go to Mobile, Ala., for repairs, not to engines and boilers, but to her hull, caused when coaling from the Iowa. She had to remain at Mobile until June 15, and then returned to Key West, when she was sent to overtake the convoy bound for Santiago. After June 16 the Dupont did not again see Key West, but remained on duty with the fleet on the south coast of Cuba. She always was ready to take not only her turn, but also that of some of the other boats on the patrol off Santiago, and she made runs which surely might be called long runs to Cienfuegos and Port Nipe and return from Guantanamo. She also ran from Guantanamo to the place the Colon ran on shore on July 3 and back to Siboney with the official report.

As to her record for steaming, I am more than sorry that I have not the actual figures here at hand, but they are on file in the Bureau of Navigation, and if I am not very much mistaken, her mileage during the war will exceed 12,000 miles, and this was from actual records on board the Dupont when the report was made. All the repairs which were made on the Dupont, with the exceptions of those on the hull mentioned above, were made by the force on board. With the exception of the enforced delay at Mobile, she never refused duty from not being ready for service, and I would gladly have the matter referred to Commander W. W. Kimball as to which of the two boats mentioned by Mr. Jackson was more often ready for duty.

I cannot agree with Mr. Jackson in his opinion that "the record for staunchness, sea-keeping power, and general excellence belongs to the Porter, which held the record of 12,900 miles of war service, on despatch and blockade duty without repairs other than those made by the force on board." I am convinced that an unprejudiced opinion, based on an examination of the logs of the two vessels, will show that the Dupont made fully as good a showing in every way as did the Porter; and furthermore—a fact which seems to have been overlooked in many cases—she came back home in fully as good a condition as when she left as far as her engines and boilers were concerned. Only slight repairs were required, while the Porter needed new boilers. It is an error to think or argue that because the Porter needed new boilers and the Dupont did not, that the former boat made more miles or saw more severe service

during the war. I might quote other boats which broke down early and often, but no one ever suggested it was because they had performed any great amount of service.

I claim that Mr. Jackson's statements are unjust to the record of the Dupont and are not borne out by the facts, and I might add that I am basing my statements from notes taken on board the Dupont the days that the events occurred; I am not relying on my memory or on hearsay, but from actual written notes which I have in my possession. If I am not very much mistaken, the Porter sailed from Guantanamo on July 10 instead of the 20th, as stated by Mr. Jackson; at any rate, she received her orders to leave on July 9, while the Dupont remained doing duty until August 3. True the Porter did go to Puerto Rico and the Dupont did not, but the latter was rolling on the blockade off Cuba during that time, which duty was fully as trying without the excitement to relieve it which fell to the share of the Porter. I do not want any one to think that I am attempting to belittle the splendid work done by the Porter, but I do ask justice for that done by the Dupont and her crew, and again I challenge the statement that the Porter is entitled to hold the record.

I hope in the near future to be able to submit to the Institute the record of the Dupont while under my command, and I trust that the other officers of the torpedo-boats will do the same, so that the service at large may see the work performed by these boats in war times.

PROFESSIONAL NOTES.

SHIPPING AND SHIPBUILDING IN THE UNITED STATES.

By James W. Ross.

Notwithstanding restrictions, shipping continued to grow in spite of all efforts on the part of mother country to the contrary, and at the time of the outbreak of the Revolution shipbuilding was the leading industry in New England. During the eight years from 1788 to 1797 shipping increased three hundred and eighty-four per cent, but this remarkable increase was exceptional, and was due to the almost universal state of war existing in Europe at that time which threw the carrying trade of the world into our hands. From 1807 to 1837 was a period of decrease in our shipping, and was followed by a second great rising period culminating in 1861, when the maximum tonnage of the United States at any one time in its history was reached, being at that time 5,539,843 tons, while that of Great Britain was 5,895,369, and the combined tonnage of all other nations, at that time, amounted to 5,800,967 tons. The aggregate tonnage of the United States in 1861 was, therefore, but little smaller than that belonging to Great Britain, and being less than 300,000 tons smaller than that of the rest of the world.

The following table, taken from the report of the Commissioners of Navigation and the records of the Treasury Department shows the rise and fall of American shipping during the last one hundred years:

Year.	Tons.	Per Cent.
1790	346,254	40.5
1795	529,471	90.0
1800	667,107	89.0
1805	744,224	91.0
1810	981,019	91.5
1815	854,295	74.0
1825	665,409	92.3
1835	588,173	84.5
1845	904,476	81.7
1855	2,348,358	75.6
1865	1,518,350	27.7
1875	1,515,598	26.1
1885	1,262,814	15.3
1895	822,347	11.7

The above statistics show to what a great extent our shipping has fallen off, particularly since 1861, when our foreign tonnage reached its highest point, until, in 1895, it was but little more than one-third as great as in 1861, and over 150,000 tons less than it was eighty-five years before, or in 1810. This startling decline is shown still more clearly when we compare the per cent of imports and exports carried by our vessels. Our ships having carried 91.5 per cent of our foreign trade in 1810, and but 11.7 per cent in 1895, or a falling off of about 80 per cent. While that of Great Britain, in 1880, was 6,574,513 tons registered. The aggregate British tonnage being somewhat over 16,000,000.

Our entire tonnage, both sail and steam, decreased from 5,539,813 tons, in 1861, to 4,057,734, in 1881, and 4,769,020, in 1897, showing a considerable fall for the first twenty years, followed by a slight increase thereafter. Iron steam vessels having slightly increased in total tonnage since 1861, while there has been a slight decrease in the aggregate tonnage in sailing ships for the same period.

The vessels built in the United States since 1880, in tons, are as follows:

Year.	Tons.
1855	583,450
1860	253,194
1880	157,409
1882	262,269
1886	96,453
1891	369,302
1896	111,602
1897	232,232

In 1856, the tonnage built in Great Britain was 935,000 tons, and in 1880 it had reached 7,903,000 tons, or nearly nine times as great as in 1856, while that of the United States for the same period was but little more than one-fourth as great as in 1855. The tonnage of iron vessels built in the United States from 1876 to 1881 was 127,298 tons, that of Great Britain over 2,000,000 tons. Of the tonnage built in 1897, 124,394 were of iron and steel.

The total tonnage of all vessels, foreign and domestic, entering our ports in 1870 was 6,270,198 tons, and in 1897 had increased to 20,002,639 tons, of which but 3,611,176 tons were American. These figures, of course, do not include our tonnage on the lakes and rivers of the United States, but merely those vessels engaged in ocean commerce.

The total tonnage built on the Great Lakes since 1880 was:

Year.	Tons.
1880	22,899
1881	73,504
1886	20,400
1891	11,856
1895	36,353
1896	108,782
1897	116,937

Of the total carrying-power of the world, 3.4 per cent is carried in American ships, while British ships carry 56.6 per cent. The newspapers of Hamburg, the third largest commercial port in the world, said, in 1897, that thirty years had elapsed since that port had seen the stars and stripes at a masthead. No merchant ship flying the United States flag passed through the Straits of Gibraltar or the Suez Canal in 1895 or 1898.

It is only in the deep sea navigation, across the ocean or to South American ports below the Orinoco, that our shipping interests are weak. American ships carry now about one-half of the total sea commerce between the United States and neighboring foreign countries, as Canada, the West Indies, Mexico, Central America, and the northern coast of South America. Our domestic water commerce, coastwise, Great Lakes, rivers and canals, is by far the largest in the world and is two and one-half times greater than that of the United Kingdom, second on the list.

The primary cause of the decay of shipping and shipbuilding may be termed a natural one, the result of the progress of civilization; namely, the substitution of iron and steel for wood, and steam for sail as a means of propulsion. So long as ships were built of wood we had an advantage over other nations, in the cost of material and in the skill and working of the same, and also in the skill of managing wooden sailing ships; when,

however, steam was substituted for sail and iron for wood, these advantages were in a great measure neutralized or wholly swept away.

Another cause put forth for the falling off of American shipping and shipbuilding is the duties on shipbuilding material in the United States and the navigation laws. It is true that the navigation laws were enforced at the time of our greatest importance in the shipping world during the early part of the present century, but at the same time all other maritime nations had similar codes, which have since been repealed or greatly modified, except in the case of the United States. From 1816 to 1840, the shipping of Great Britain remained almost stationary, but when duties were removed it increased immediately, and still more so when the navigation laws were repealed in 1849. Another cause for the decline in shipping is said to be the excessive fees charged ships entering the United States ports for pilotage, health fees, tonnage duties, etc., which amount to a great part of their revenues.

On the other hand, there are those who take the opposite view of the case and argue that the navigation laws and duties on ship materials were the very cause of our prosperous shipping trade at the beginning of the present century, and that as soon as these were all modified, as in the case of the reciprocity laws, our trade fell off. On the whole, though, it seems more probable that the falling off in our shipping was not greatly affected by these measures, either one way or the other, and that the chief causes of the decline were the changes that took place in shipbuilding, thus throwing the advantage of skill and cheapness of production into the hands of the British, who were better able to use the new materials than we were.

For over a century and a half shipbuilding in the United States was limited to the construction of wooden vessels, and their sole means of propulsion was by the use of sails. But the beginning of the nineteenth century was destined to make the first great change in shipbuilding in this country, for with its coming came the introduction of the steam engine as a new means of propulsion. This new and wonderful motive power was first successfully applied to ships in this country by Robert Fulton, whose Claremont, built in 1807, was the first successful steamboat in the world. The Claremont was a side-wheel steamer, 133 feet long, and it is said to have attained a speed of five miles per hour on her trial trip from New York to Albany. The following years were marked by the building of a number of other steamboats of a similar type, most of which were employed on the Hudson River, between New York and Albany. In 1814 appeared the first steam warship ever constructed. This vessel, built by Robert Fulton, and known as the Demologos, was constructed in 1814, and consisted of two hulls joined together with a canal in the center for the paddle-wheel, and is said to have steamed at the rate of five miles and a half per hour. The Demologos was never used in battle and her value as a fighting ship was, therefore, never ascertained.

The first steamship to cross the Atlantic was the Savannah, built in New York in 1819, and crossing from Savannah to Liverpool in twenty-five days. This trip, however, was not accomplished entirely by the use of steam, for the Savannah was also fitted with sails and the paddle-wheels were so arranged as to be folded on deck during favorable winds and the sails used, so that steam was employed only during weather unfavorable for the use of sails.

The great drawback at this time for the use of steam as the sole motive

power was the great amount of fuel necessary to carry a vessel across the Atlantic, it having been estimated that more than four times as much coal was necessary to each horse-power as is required now; for this reason it was many years before steamships were sufficiently perfected to make it possible for them to cross the ocean under steam power alone. The Great Western, a British ship, making the first trip in 1878, from Bristol to New York, in fifteen days.

American steam shipping, however, did not assume any great proportion until 1848, but from that time it increased so rapidly that in 1851 it was practically equal to that of Great Britain. In 1850, the first American line of steamships to compete in the transatlantic trade known as the Collins' Line was established. Four ships were built, the Arctic, Baltic, Atlantic and Pacific, being larger and swifter than any other ships afloat and having vertical bows, the first of the kind ever built. For a time this line was the finest in the world, but disaster seemed to follow the company, two of their ships being sunk, one of which was never heard of again after starting on her trip across the Atlantic. Some few years later the company failed.

Meanwhile other great changes had come about in the construction of ships; namely, the use of iron instead of wood. In 1834, the John Randolph, built in England for a Savannah man, was the first iron ship ever seen in the United States, although the first vessel to be constructed of this material is said to have been built in Great Britain in 1818. The first large vessel to be constructed of iron was the British ship Great Britain, built in 1843, and was also fitted with a screw propeller, being the first ship of large size in which the screw had ever been used, although first introduced by John Ericsson in 1836.

The next important change in shipbuilding came with the introduction of the compound engine or the old-fashioned low-pressure jet-injecting type. With the old form of engine the great drawback to high speed was the great amount of coal required per horse-power, and the impossibility of high pressure. The compound engine, to a great extent, changed these conditions, and together with the advancement in boiler-making, made a much higher pressure possible, with a great saving in the amount of coal required per horse-power; it having been said that but 2½ pounds were now required for each horse-power where 4 had been necessary with the old form of engine, the compound engine was used in 1862, by the Cunard Line of steamships, and came into general use in 1874, when it was introduced into the ships of the Inman and White Star companies.

But at about the same time the compound engine came into general use, a still greater improvement made its appearance in the triple-expansion engine. This new type was first used in 1874, but did not come to be generally adopted until about 1885. With its introduction came a still greater development of speed in steamships, owing to the higher pressure and to the further saving of coal, which was said to be as much as 20 to 25 per cent less than the compound engine required. This wonderful improvement was followed a few years later by the quadruple-expansion engine, making a still greater saving in the consumption of coal, at the same time making higher pressure possible, and, hence, greater speed. The St. Louis and St. Paul, our two fast liners, are fitted with these engines, the first large ships to which the new principle has been applied.

Steel came to be used in ship-construction about 1880, although not very generally adopted until some years later. Its introduction brought about

a still greater improvement in shipbuilding, owing to the fact of its greater strength than is possessed by iron, hence a ship may, by its use, be made lighter and at the same time stronger than by the use of iron. Steel has not been used until within the last few years for the construction of merchant ships, but has been used almost from the time of its adoption, in 1880, in the construction of our ships of war.

Twin screws first came into general use in 1887, when the City of New York and the City of Paris were built for the Inman Line Steamship Company, and soon after the same principle was applied successfully to the White Star Line steamships Teutonic and Majestic.

The system of multiple screws was still further enlarged upon about three years later, with the introduction of the third screw. This arrangement has been successfully carried out in the Columbia and the Minneapolis, our two fast cruisers, and driven by three 3-cylinder vertical inverted, triple-expansion engines, attain speeds of 22.81 and 23.073 knots per hour respectively on four-hour runs. The fastest time ever made by a cruiser.

The special advantage of triple screws are, smaller size of the separate parts of the machinery, enabling higher rotative speeds to be employed with safety, and greater economy than ordinary cruising when one engine working up to about its natural draft full power will give a fair cruising speed with economy of fuel. It is far from economical to run large twin-screw engines designed for nineteen knots and upward at speeds of nine and ten knots. Engine friction alone forms such a large percentage of the power developed, to say nothing of the increased cylinder condensation due to the slower rotative speed, that the economic performance, as measured by coal per horse-power, is very low. The total horse-power being divided between three shafts also vastly decreases the chances of the total disablement of the ship.

In 1892 a bill was passed by Congress, at the proposal of Dr. Griscom, president of the International Navigation Company, admitting the New York and Paris to American registry on the understanding that two other ships of at least equal tonnage would be built in the United States. The two ships built according to the provision of this act, the St. Louis and St. Paul, were launched in 1895. A short description of them may serve to show the state of advancement in shipbuilding in the United States, and further as an illustration of the most recent improvements in ship-construction.

St. Louis and St. Paul are the largest ships ever built in the United States, and, with but few exceptions, the largest and most powerful of any ships in existence. These vessels are sister ships, 545 feet in length, 62 feet and 9 inches beam, and 42 feet and 4 inches deep, with a light displacement of 10,700 tons. The motive power is furnished by a pair of vertical inverted quadruple-expansion engines actuating twin screws, to carry a working steam pressure of two hundred pounds, and capable of developing 20,000 indicated horse-power. The ships themselves are built of steel, and every bit of material used in them is of domestic production. They are of American model and design, and were built by American skill and muscle.

When the act of admitting the New York and Paris to American registry, on condition of building two ships of equal tonnage in American shipyards, was passed, the British press ridiculed the idea. "Such ships could not be built in the States," they said; later certain naval architects

from Great Britain visited our shipyards and saw such ships actually in process of construction. Now the British newspapers admit that our yards are capable of turning out ships equal to the product of any shipyard in the world.

St. Louis and St. Paul have proved to be all that was expected of them; safe, commodious, comfortable, luxurious and fast; free from vibration and among the stanchest and ablest sea-boats afloat. A striking incident of the latter quality occurred in a recent passage, when the St. Louis and Campania, being abreast in a gale heavy enough to buffet and knock down the speed of the latter, the St. Louis plunged through it at nearly full speed without the slightest distress or discomfort.

The St. Louis and St. Paul have taken the passage record from New York to Southampton, St. Paul holding the westward record of six days thirty-one minutes, and the St. Louis the eastern record in six days ten hours and ten minutes.

Having thus proven our ability to compete in the construction of passenger vessels with our British cousins across the Atlantic, let us now see how our ships of war compare with theirs. It has been but a few years since what is known as the reconstruction of our navy began. In 1882, the first of our present new navy, the Atlanta, Boston, Chicago and Dophin were, by Congress, authorized to be constructed. Since that time we have added over forty vessels of modern type, and with but few exceptions built of American material and by American workmen, and from American designs. We have now reached a point where we are able to compete successfully with any nation in the world, and, in fact, our ships are said by many to be superior to those built in British shipyards.

An eminent English naval authority, in an article published in *The Fortnightly Review*, July, 1894, compares our battleships of the Indiana class with similar ships in the British and French navies, and, after noting the size, speed and armor, says:

"It will be observed that the Indiana and Iowa compare unfavorably in speed with both Renown and the Jaureguiberry, but in almost every respect they seem to be immensely, nay, crushingly superior; and I do not regard great speed of supreme importance in a battleship. What, for example, could be the value in practice of the Renown's superior speed as against the Indiana's? It might, it is true, enable our ship to force an action, but with an opponent so greatly superior in gun-fire our ship could scarcely hope, other things being equal, to achieve success.

"If the two ships, engaged bow to bow, stern to stern, or bow to stern, the United States ships could give blows much more numerous than those of the British ship, and in the aggregate nearly thrice as heavy; even if they engaged broadside to broadside the aggregate energy of the American fire would be much more than double that of the British. Put our huge Royal Sovereign or our coming Prince George, as our champion instead of our Renown, and we will not fare much better, for the Americans distribute their guns much more advantageously than we do, and their battleships, which I have sighted, represent more sensible compromise of the rival claims of speed, radius of action, gun-power and armor than any of ours. If our battleships be unequal to the task of engaging another battleship of inferior displacement, superior speed will avail the former little, unless to enable her to run out of danger; yet, is not the main object of a battleship after all to fight? In the war of 1812 we were obliged, much against our will, to take lessons from the United

States on the subject of the proper way of gunning frigates. We might do worse now than take lessons from the United States on the subject of the proper way of gunning battleships; and, also, of gunning cruisers, for the American cruisers are as superior to ours as the American battleships are."

The chief cause, as we have seen, of the decline of our shipbuilding industry was the change from wooden to iron ships, thus throwing whatever advantage there had been in our favor into the hands of Great Britain, owing to the fact that the latter country was better able, at that time, to produce iron, and could do so more cheaply than was possible in the United States. But we have made such rapid progress in the iron industry during the last few years that we are no longer at a disadvantage in this respect, but, in fact, are able to produce iron and steel cheaper than it can be produced in Great Britain. We have not yet reached our maximum power in the production of iron. Our furnaces are much larger than those in Great Britain and of a more modern type, and with the vast amount of iron to be found in the United States, and the large amount of capital which may be employed in the iron industry, there seems to be no reason why we should not continue to produce iron and steel at the same, if not at lower, rates than is possible in Great Britain. Another advantage we have is the cheapness of fuel. American coal is the cheapest in the world. The cost of production has generally decreased during the last few years. In 1880, the average annual output per employee was 190 tons; it is now about 550 tons. In 1882, the output of pig iron was 4,623,323 tons, and of finished iron and steel 3,500,000 tons. In 1887, these figures had reached 6,417,148 and 5,250,000 tons respectively, while in 1897 these figures were 9,652,680 and 7,000,000 tons.

American steel rails are now being supplied on contracts to British India, Russian Asia, and the West Indies, Canada, South Africa, Hawaii, and even to Ireland. In one month last year the two largest steel rail companies are said to have booked between them no less than a half-million tons, the largest proportion of which was for export. Nor is this surprising, for the prices have steadily fallen during the last few years; thus, in 1896, the price of steel rails was $24.25 a ton in the United States, $26.80 in Germany, and $23.75 in Great Britain.

In 1898, the prices were $19.00 in the United States, and $28.75 in Germany, and $22.50 in Great Britain. In 1898, the exports of iron and steel from the United States amounted to $70,367,527 as against $57,497,872 in the previous year.

The *London Statist*, one of the principal financial journals of England, published not long ago, an article entitled "American Ships, Iron and Steel," in which, after dwelling at some length upon the rapid development of our iron industries during the last few years and making some prophecies in regard to our future position in the shipping world, the following statement was made:

"The point we have sought to bring out is that America has now so developed her iron and steel industries that she must find fresh outlets for her products. Such outlets she is finding, as we believe, with profit in foreign markets, for certain products. For other products, however, she will need to create a new shipbuilding industry of her own, and what has been done, or is being done in that direction, we must reserve for future examination. No thoughtful man, acquainted with the American character, who considers the situation, can fail to perceive that the greatest

competition to be faced by British industry and enterprise in the future is that of American shipbuilding. It may be deferred a few years, but it is bound to come."—*Scientific American Supplement.*

BRITISH SHIPBUILDING.

From an address before the Institution of Naval Architects.

This has been a year that will never be forgotten in the annals of the mercantile marine of Great Britain. Her Majesty's government, on the outbreak of the war in South Africa, found themselves compelled to rely solely upon the merchant steamers of the country, in order to transport to the scene of operations the largest military force that has ever been sent across the seas by any state in the world's history. It is satisfactory to learn, on the authority of the First Lord of the Admiralty, that the work has been admirably performed. As far back as February 17, 181 transports and freight ships had already been employed to carry over 132,000 officers and men, together with 50,000 horses and mules, and the stores and material for this large force. These figures are exclusive of the troops, horses, etc., conveyed from India and the colonies. Though the distance traversed was 6000 miles, not a single life has been lost during the operation, and the few mishaps that have befallen the steamers have been due to the risks of navigation. Since the date of the First Lord's speech, the figures mentioned above have been very considerably increased; but, nevertheless, the immunity from accident continues. The fact that it has been found possible to confide with perfect security, the safety of its principal fighting force to the ships of private owners entitles me to congratulate them, as well as the builders and the registration societies which framed the rules under which most of the vessels and engines were constructed, upon having created a mercantile fleet of such efficiency that the state was enabled to make full use of it in its hour of need. We have always been accustomed to reckon the mercantile marine as one of the greatest of our commercial assets, but I doubt if the people of this country have hitherto been aware that they also possessed in it a military factor of the first importance. It is, therefore, on national, as well as on commercial grounds, that I am able to congratulate our shipbuilders upon the fact that, in the year 1899 they have again broken all records with an output of mercantile shipping amounting to 1,416,791 tons, a figure which exceeds the total of the previous year by 49,000. In addition, warships having a total displacement of 168,590 tons were launched in British yards, of which about two-thirds were built in private establishments. The orders now in hand, it is true, show a slight diminution when compared with the figures of the corresponding period last year. The latest returns prove that 1,306,751 tons are now under construction, as against 1,400,000 tons a year ago; but this falling off will hardly occasion surprise when we consider how intensely active the shipbuilding industry has been since the termination of the great labor dispute in 1897. The returns bear witness to the continually increasing size of merchant steamers, for no less than sixteen vessels of 10,000 tons and upwards were being built, of which eight were launched during the year, exclusive of the Oceanic, to which I referred in my last annual address. Of these, the largest was the Ivernia, of 13,900 tons, which we had the advantage of inspecting, thanks to the kindness of C. S. Swan and Hunter, on the occasion of our visit to Newcastle-upon-Tyne.

The sale of British vessels to foreign owners appears to be going on at an increasing rate. During the last year no less than 609,589 tons were transferred to foreign flags, this being the largest figure on record. Nevertheless, the net additions to the British register were considerable, having amounted to 399,865 tons. The number of ships on the register, however, shows a diminution of 195, in consequence of large removals of sailing vessels from the lists.

Our foreign friends, who are such active supporters of this Institution, have, I am glad to say, fully shared in the prosperity of the shipbuilding industry. In France 90,000 tons of mercantile vessels and warships, of 65,000 tons displacement, were launched. The construction of sailing ships, almost abandoned elsewhere, continues to flourish under the French bounty laws. The returns include two such vessels, the Ville de Mulhouse and the Ville de Havre, each of 3214 tons.

The returns for the United States, Germany, and Italy all show considerable increases over even the noteworthy figures of the previous year. About one-third of the tonnage launched in the States was for service on the Great Lakes. It may give an idea of the importance of the water-borne commerce of these inland seas if I mention that eleven steamers of upwards of 4000 tons, and two sailing barges of over 5000 tons each were launched last year for the lake trade.

The Germans have again distinguished themselves by the construction of several steamers of very large size. These include the Patricia, of 13,292 tons; the Grosser Kurfürst, of 12,500 tons; and shortly after the close of the year they launched the Deutschland, of about 15,500 tons, which, next to the Oceanic, is now the largest vessel afloat.

Turning to the Royal navy, the new shipbuilding programme appears at first sight to be a somewhat modest one. In the coming financial year it is proposed to lay down two battleships, six first-class armored cruisers, one second-class cruiser, and six small vessels. It must not, however, be forgotten that we have already under construction a large number of armored and unarmored vessels. In the course of the coming year there will be building or completing the following ships: Seventeen battleships, twenty armored cruisers, one first-class protected cruiser, one third-class cruiser, and thirty-six other vessels of various classes; a very tolerable-sized fleet in themselves. I cannot, however, refrain from expressing the regret which I share with the naval authorities that, owing to a variety of circumstances, such as the non-delivery of material, the rapidity of construction, of which we have in the past been so justly proud, has not during the last two or three years been fully maintained. So far as I have been informed, the chief causes of delay have been owing to restricted output of the best class of propelling machinery and of armor-plate. The situation has been described by the First Lord of the Admiralty as one of some difficulty. In my opinion it might resolve itself into one of some gravity, or even danger. I cannot myself believe that we have reached the limit of our producing power in these two directions, or that we are straining our unrivalled resources. The difficulty of procuring armor-plate seems to be the more acute of these two questions. I venture, with the utmost respect, to suggest that two courses are open to the government. Either to extend by means of orders guaranteed over a series of years, the number of firms capable of supplying armor-plate; or for the state itself to undertake its manufacture. I am aware that this latter course is open to serious objections, which I need not

particularize, but I am confident that the people of this country are so fully alive to the absolute necessity of possessing an all-powerful fleet that they will not consent, year after year, to see money which they cheerfully grant for constructive purposes, either allowed to lapse, or else devoted to purposes other than those which their representatives intended it for.

It must be satisfactory to all those who closely study the conditions of efficiency and mobility of a fleet to learn that the Admiralty are giving their earnest attention to the question of fleet auxiliaries. While it is highly desirable that every warship should be, to the greatest possible extent, self-contained, no modern squadron can be considered independent unless accompanied by specially fitted colliers, repairing-ships, magazine-ships, hospital-ships, and distilling-ships. Looking to the extreme rapidity with which modern naval warfare is likely to develop, it is to be hoped that too great reliance will not be placed upon vessels improvised at the last moment to fulfil these purposes.

Another question, which might become a burning one, is the restriction upon the employment of wood in all fighting ships. Many foreign nations are, I believe, entirely abandoning the use of wooden decks and wood fittings in their military marines. If we are not following their example as closely as some might wish, it is because our ships have to keep the sea for longer periods than do those of our neighbors, and we are bound, therefore, to give greater consideration to their habitability; but, while we do not lose sight of this important factor in the health and efficiency of our ships' companies, it is earnestly to be hoped that all inflammable material will be cut down to the narrowest possible limits, and be made easily removable when clearing ships for action.—*The Engineer.*

THE IMPERIAL JAPANESE NAVY.*

By Rear-Admiral C. C. P. FitzGerald, Associate.

The first real start made by Japan in the production of a modern navy seems to have been the purchase of the ironclad Stonewall Jackson from the United States government in 1866. She was a small ship of only 1300 tons burden, but she carried a 10-ton gun, besides some smaller ones, and was a powerful ship of her day; she was re-named the Adzuma. The first ship built in England for the Japanese government was the Foo-So. She was built at Poplar by Samuda, from designs by Sir Edward Reed, and was launched in April, 1877. She was a broadside central-battery ship, bark rigged, 220 feet long, 48 feet beam, 3718 tons, double screw, speed 13 knots, engines by Penn. This ship was followed by the Kon-go, Hi-yei, and Rin-jo, all small ironclads not exceeding 2300 tons, but carrying powerful armaments for their size. There were also about half a dozen unarmored ships of little fighting value. This was the state of the Japanese navy in 1880. Five years later—1885—Japan had only added one small ironclad to this list; but there were "built and building" for her several fast and powerful cruisers, armed with Krupp and Armstrong guns. The ironclads, with the exception of the Foo-So, were built of wood. Five years later—1890—she had again only added one ironclad to her list, in the shape of an armored gunboat; but she had by this time provided herself with a considerable squadron of fast and well-armed

* Institution of Naval Architects, April, 1900.

cruisers, built in various foreign countries. By 1895, although she had not actually added to her list of armored ships, there were building for her in England two battleships of the most powerful type, exceeding 12,000 tons displacement, and with a proposed speed of 18 knots; she had also added considerably to her list of fast cruisers. One of these, the Yoshino, built at Elswick, had a measured-mile speed of 22.5 knots.

There can be no doubt that the Chino-Japanese war gave an immense impetus to the development of the Japanese navy; not only were ships captured from the Chinese, some of which were repaired and are now in commission, but large orders were placed abroad for warships of all classes, including torpedo craft, and the Japanese also set to work to build ships in their own dockyards. The Japanese navy now stands as follows, eliminating ships which appear to be of insignificant fighting value, but including those which are expected to be ready during the current year:

Battleships.

Fuji	Thames Iron Works.
Yashima	Elswick.
Shikishima	Thames Iron Works.
Asahi	John Brown and Co.
Hatsusi	Elswick
Mikása	Vickers and Co.

These are first-class battleships in the fullest sense of the term, ranging in tonnage from the 12,300 of the Yashima to the 15,000 of the Asahi, Hatsusi, and Mikása. Their speeds are all at least 18 knots, and they are armed with the most powerful modern guns, and considerable areas of their sides are protected by the latest and most up-to-date face-hardened armor. Four of the six carry more armor and more guns than British first-class battleships, but less coal. There is also the Chinyen—late Chin Yuen—captured from the Chinese, German built. I have seen her quite lately. She has been thoroughly repaired, and is now in commission, and although she cannot be classed as a first-class battleship, being of only 7220 tons, and 14 knots speed, she is a powerful ship of her class. There are also three small ironclads—Fuso, Hi-yei, and Kon-go—built in England in the seventies, before alluded to, and the Hei Yen, captured from the Chinese; they are of very small fighting value, and three of them are used as training-ships.

Armored cruisers.—Although Japan won the battle of Yalu with second-class cruisers fighting against armored ships, her statesmen are not under the delusion that second-class cruisers will be sufficient to meet the growing needs of their rapidly expanding empire, and they are, therefore, adding to the fleet six very powerful armored cruisers of about 9800 tons displacement and about 20 knots speed:

	Tons.	Speed.	Armament.
Tokiwa Asama Idzuma Iwate	9750	21.5	Four 8-in., fourteen 6-in., and twelve 12 prs.

These are all Elswick ships, designed by Mr. Philip Watts. The Tokiwa and Asama are completed, the Idzuma will be delivered about the middle of this year, the Iwate towards the close of it. The Idzuma, of 9436 tons, but the same armament, and 20 knots speed, is building at St. Nazaire, by the Société de la Loire, and is to be ready this year. The Yakuma, of 9850 tons, and the same speed and armament as the Idzuma, is building at the Vulcan Works, Stettin, and I am informed she is to be ready this year. The above ships constitute a squadron of six extremely powerful

vessels, call them what you will, battleships or cruisers; at any rate not a few of the so-called "naval experts" think such ships are fit to "lie in the line" and take their place amongst battleships. They are at least as powerful vessels as some that are classed as second-class battleships in our own and some foreign navies, and they have a great advantage in speed. Japan owns another armored cruiser, the Chiyoda, built in Glasgow in 1890, with a nominal speed of 19 knots; she is a small ship of only 2439 tons, and she cannot be assigned a very high fighting value in the present day, though she took part in the battle of Yalu.

Unarmored Cruisers, Second-Class.

	Tons.	Speed.	Armament.
Chitose Kasagi Takasago	4760 4784 4160	22.5	Two 8-in., ten 4.7-in., and smaller guns.

The Chitose was built at San Francisco, the Kasagi at Philadelphia, and the Takasago at Elswick.

*Yoshino	4150	22.5	Four 6-in., eight 5-in., and smaller guns.

This ship was built at Elswick.

*Akitsushima	3100	19.0	Four 6-in., six 5-in., and smaller guns.

This ship was built in Japan.

*Naniwa *Takachiho	3650	18.7	Two 10-in., six 6-in., and smaller guns.

Built at Elswick in 1885.

We come now to a group of a peculiar type of cruiser, carrying one very heavy gun forward, and a battery of light guns on the main deck aft.

	Tons.	Speed.	Armament.
*Matsushima *Itsukushima *Hashidate	4210	16.0	One 12-in., eleven 5-in., and smaller guns.

NOTE.—The ships marked * took part in the battle of Yalu.

The two former ships were built in France in 1889; the latter in Japan two years later. Such an armament appears to be out of place in a cruiser, and a nominal speed of 16 knots to be inadequate. It does not appear that this type is likely to be repeated.

Third-class cruisers and small craft.—Japan possesses several third-class cruisers of good speed, capable of acting as scouts. She has also a considerable number of small vessels of low speed and but little fighting value, which it would be waste of time to describe. But there are six gunboats of the Chinto class, captured from the Chinese, carrying one 11-inch gun. These might be useful as coast-defenders.

Torpedo flotilla.—The peculiar nature of the Japanese coast-line, with its numerous harbors, and the Inland Sea with its archipelago of islands, are physical features in Japan which offer special advantages for the use of torpedo-boats; and she is, therefore, providing herself with a powerful torpedo flotilla of the most modern type of vessels. Messrs. Yarrow, Thornycroft, Normand, and Schichau are all building either torpedo-boats or destroyers for the Japanese government, and some are also being built in Japan. A torpedo transport on the plan of our own Vulcan and the French Foudre is projected, but my information does not enable me to state whether the order has actually been placed or not. Yarrow and Co. have just completed six destroyers of 31 knots' speed and upwards, and the same firm has now in course of construction ten first-class torpedo-boats for the Japanese government. Thornycroft and Co. have also just com-

pleted six destroyers of about 50 tons less displacement than the Yarrow boats, and with speeds of 30 knots and over. Japan already has in commission and in reserve, a considerable number of first and second-class torpedo-boats, some of these being constantly used for exercise. It is interesting to note that an armor-plated torpedo-boat named the Katoka, 166 feet long, with 9 feet 6 inches beam, built for the Japanese government by Yarrow and Co., in 1885, led the torpedo attack both at Port Arthur and Wei-hai-wei. It seems that the Japanese not only know how to order a good article, but to use it when they get it.

Dockyards.—There are three Imperial dockyards in Japan—Yokosuko, Kuré, and Sassebo. They are all capable of being effectually defended. A fourth, Maisuru, on the northwest coast of the main island, is also in course of construction. Sassebo can only be approached through narrow and tortuous channels, and from its natural position, may be considered absolutely unattackable from the sea. Kuré is in the Inland Sea, and its position also is naturally a very strong one; the islands around it are being strongly fortified, and it will shortly be impregnable to sea attack. It is, moreover, to be remarked that with the powerful torpedo flotilla Japan has already got, and is still further increasing, hostile ships operating in the Inland Sea would be likely to have a bad time. Yokosuko is in the gulf of Yeddo, and very favorably placed for defense. The heights around are already fortified, and the works now in progress at the entrance to the gulf will protect not only Yokosuko, but also Tokyo and Yokohama, and forbid this large stretch of enclosed water to any hostile squadron. Nagasaki, where there is a private shipbuilding yard that turns out large merchant steamers, and where there is one first and one second-class dock, is being strongly fortified; and from its position it is a place of strategic importance. At Hakodati, in the North Island of Japan, the harbor is being artificially improved, and, although there is no dockyard here, the port is being fortified as a harbor of refuge. This place bears a striking resemblance to Gibraltar. At Oterrani, also in the North Island, extensive harbor works are in progress, an interesting description of which was lately given in *Engineering*.

Up to the present the Japanese dockyards have not undertaken to build a battleship, and the largest cruiser they have built is the Hashidaté, of 4200 tons and 16 knots speed; but they hope soon to be able to build first-class cruisers at Yokosuko, and eventually battleships. At this dockyard there is a first-class modern dock, in which one of the heaviest battleships of the British navy—the Victorious—was lately docked for cleaning purposes, and I never saw a similar operation more quickly, more quietly, nor more methodically performed in any English dockyard. In the *Jiji Shimpo* (*Times* of Japan), of February, 1899, Mr. S. Sassow, Chief Director of Naval Construction, writes as follows concerning Yokosuko dockyard: "This dockyard was established during the Tokugawa regency by the Shogunate in 1866. French officers, comprising naval constructors and engineers—Mons. Verner being the chief director—were engaged, together with a considerable number of leading workmen, for originating the work and for instructing Japanese workmen; several wooden ships have been built here. In 1875 the services of the greater part of the French employees were dispensed with, and the administration passed entirely into our own hands. . . . We are now building entirely of steel. Our artisans in all branches of shipbuilding and engineering have now attained to a considerable skill. . . . Hitherto the limit of size at Yokosuko

has been 5000 tons; but it is intended to enlarge the dockyard so as to be able to build cruisers of all classes; and in course of time we expect to be able to build battleships. All materials have to be purchased abroad, even for building cruisers."

With regard to steel armor-plate manufacture, Mr. Sassow says: "Should such be established in Japan, it would hardly be able to manufacture plates within six years from starting. With the experience of six years even they will probably find that it will be only after many years of further experience they are able to turn out plates of uniform thickness." Under these circumstances, the armor-plate manufacturers of Great Britain need not feel any immediate alarm of dangerous competition from Japan.—*The Engineer.*

THE UNITED STATES CRUISERS OF THE DENVER CLASS.

The Denver is one of a class of six that were provided for in the Naval Appropriation Bill for the fiscal year ending June 30 next. The vessels were first known as protected cruisers 14 to 19, but have since been named the Denver, Des Moines, Chattanooga, Galveston, Tacoma, and Cleveland.

The vessels are, of course, to be twin-screw, the propelling engines being right and left-handed; they are of the inverted, direct-acting, four-crank, triple-expansion type. There is one piston-valve for the high-pressure cylinder, and two for each intermediate-pressure cylinder, and one flat slide valve for each low-pressure cylinder.

Diameter of high-pressure cylinder	18	in.
" intermediate-pressure cylinder	29	"
" low-pressure cylinders	35½	"
Stroke	30	"
Revolutions at full power per minute	172	
Steam pressure in boilers	275	lb.
" " at engine	250	"
Diameter of crankshaft	9¼	in.
" crankpin	9½	"
Length of crankpin	11	"
Diameter of axial hole in shaft	5	"
" piston valves	11	"

The sequence of cranks in turning centers is in order as follows: High-pressure, intermediate-pressure, forward low-pressure, and after low-pressure. The order of the cylinders is forward low-pressure, high-pressure, intermediate-pressure, and after low-pressure. The collective indicated horse-power of the propelling and circulating pump engines was originally designed to be 4500, with the main engine making about 172 revolutions per minute at the steam-pressure named; viz., 250 pounds at the engine. The engine bedplate is of cast-steel. The crankshaft for each engine is forged in two pieces, the shaft for the forward low-pressure, and the high-pressure cylinder, forms one piece, whilst that for the intermediate-pressure cylinder and the after low-pressure cylinder are formed of another piece. All crank, thrust and propeller shafts are hollow. The shafts, piston-rods, connecting-rods, valve-rods, eccentric-rods, and working parts generally are of forged nickel-steel. There is in the design a single-acting air-pump worked from the crosshead of the forward low-pressure cylinder.

There will be one separate cylindrical main condenser to each set of engines, placed in the wings of the engine-room, as usual with an arrange-

ment of machinery of this nature. The total cooling surface of each, as designed, is about 3000 feet, or 6000 feet in all. Each main condenser will have one centrifugal circulating pump. There will be two auxiliary condensers, each with a cooling surface of about 450 feet, and these condensers will have combined air and circulating pumps. The auxiliary condensers are of the cylindrical type and are placed athwartships against the after engine-room bulkhead. The propellers are of bronze and are right and left-handed, turning from the ship.

According to the original design, it was specified that the boilers should be six in number and of the water-tube type, giving steam for an aggregate of 4700 indicated horse-power. The total grate surface was at least to be 300 square feet, and the total heating surface about 13,200 square feet. The boilers were to be in two compartments with fire-rooms athwartships, and there were to be two smoke-pipes for all the six boilers. "The forced-draft system," it is stated in the proposals, "will consist of three boilers discharging into airtight fire-rooms. The air for combustion will be heated by the hot gases circulating among or through tubes arranged in the uptakes or in the upper part of the boiler casing, and will be conveyed through ducts fitted with dampers to closed ashpits." In addition, the following engines are to be supplied and worked by steam, viz.: Steering engine, capstan engine, four deck winches, two ash hoists from each fire-room, dense air machine with capacity of 1 ton of ice per day, engine for machine tools, and evaporating and distilling plant in two units, each having a capacity of 4000 gallons per day. The following auxiliary machinery is to be electrically operated: Blowers for hull ventilation, and two winches for hoisting ammunition.

The main elements, according to the latest advices, may be here added:

Length on water line	292 ft.
Beam at " "	44 "
Trial displacement	3200 tons
Greatest draft, full load	16 ft. 11 in.
Total bunker capacity, not less than	700 tons
Coal on trial	470 "
Feed-water, trial	40 "
Speed on trial, at least	16½ knots
Full load displacement	3500 tons

The above particulars are taken from the *Journal of the American Society of Naval Engineers*. We are also indebted to the same valuable publication for the following interesting details of weights which are taken from the United States Naval Department's design:

	Tons.
Guns, mounts, shields, &c., about	98
Ammunition, ordnance, stores, and outfit, about	155
Machinery complete, about	405
Engineers' stores, about	22
Fresh water for steaming purposes	40
Total coal	700
Boats and outfits	13
Masts and spars	14
Electric plant and electric outfit	29
Equipment, including anchors, chains, rigging, &c.	72
Officers, crew, and outfit	37
Miscellaneous and provisions, and clothing stores	12

As previously stated, the tenders, or bids, for these six cruisers have been lately received, and it will be interesting to consider them in connection with the proposals put forward by the United States government, more especially as the procedure followed in America differs somewhat from our own. The Naval Appropriation Bill providing for these ships was that which dealt with the provision of vessels for the United States

navy up to the end of the present fiscal year, which terminates on June 30 next. There were authorized to be constructed by contract, three seagoing coast-line battleships, three armored cruisers, and these six protected cruisers. The general particulars of the ships were laid down in the bill, and they are each to cost, exclusive of armament, not more than $1,140,800. The Secretary of the Navy was directed to award the contract to the "lowest responsible bidder, having in view the best results and the most expeditious delivery." Not more than two of the seagoing battleships, and not more than two of the protected cruisers, were to be built in one yard or by one contracting party. It was further provided "that one and not more than one of the seagoing battleships, and one and not more than one of the armored cruisers shall be built on or near the coast of the Pacific Ocean." The President was, however, allowed to exercise his discretion in regard to the latter provision if it was found that the vessels could not be built on the Pacific side at a cost not exceeding 4 per cent. above the lowest accepted bid for the other ships.

There is a good deal that is interesting in the provisions of this bill, especially when considered in conjunction with the armor-plate questions in which the United States Congress has recently thought fit to interfere with not very fortunate results. No doubt a wise discretion is exercised in fostering shipbuilding enterprise on both ocean coast-lines of the country, as thereby the naval strength of the nation is increased, although a cynically inclined American citizen might be apt to attribute the procedure to the influence of Pacific coast votes. But in any case it would be more satisfactory, we should think, to have these matters left to the Secretary of the United States Navy and his professional advisers; as, in this country, they would be left to the First Lord of the Admiralty. Unfortunately these wider questions of national policy are the kind of things our First Lords never seem to consider; because, it may be presumed, they are subordinate to the Treasury—which never recognizes anything more imperial than the lowest tender—and also because they are afraid of questions in the House. The "awards" for the six cruisers were made on November 27 last, as follows: Galveston, Wm. R. Trigg & Co., 24 months, $1,027,000; Chattanooga, Lewis Nixon, 30 months, $1,039,966; Cleveland, Bath Iron Works, 30 months, $1,041,650; Tacoma, Union Iron Works, 27 months, $1,041,900; Des Moines, Fore River Engineering Company, 30 months, $1,065,000; Denver, Neafie & Levy, S. and E. B. Company, 30 months, $1,080,000.

These contracts are for the department's designs with a speed of 16½ knots. There was offered by one firm a lower price than any of those named, namely, $954,500, but their tender was not accepted. There were also three bids somewhat higher. The closeness of some of the tenders is quite a coincidence, and indicates how very well the estimating department is managed in some of the works.

Contractors were invited to submit tenders on modified designs at higher speeds, but the American Board of Construction decided to recommend acceptance only of the department plans. It will, however, be interesting to give some of the tenders made by contractors on their own plans. The firm who gave the lowest price, not accepted, for the department design, made a bid of $1,059,500 for a 17½-knot ship, or only $105,000 for the extra knot. For an 18-knot ship with Thornycroft boilers, Messrs. W. R. Trigg & Co. bid $1,041,000, or only $14,000 for the extra speed, say 2800*l.* for a knot and a half. That appears surprisingly

cheap, but the Fore River Engine Company were even more liberal, and offered the knot and a half for nothing, being willing to take $1,065,000, whether the vessel steamed 16½ or 18 knots. It must be remembered, however, that the latter speed was to be obtained on their own designs, a circumstance that makes a good deal of difference when dealing with governments. For an 18½-knot ship the Fore River Company asked $1,100,000; and for a 19-knot ship with Thornycroft boilers, Messrs. W. R. Trigg & Co. asked $1,079,000, or only $52,000 over their 16½-knot price. Most of the firms offered lower prices if awarded two ships.

It would seem from these figures—for we may presume that the contractors did not offer unserviceable or absurd designs—that the United States authorities do not set an inordinately high value on speed; as our own naval authorities have been accused of doing. Admiral Hichborn, who corresponds to our Sir William White, being head of the United States Construction Department, has expressed his disapprobation of "show vessels" and "fancy results." Probably his department look on excessive speed as one of the "fancy" or "showy" attributes. The value to be attached to such qualities, however, is a matter for seagoing naval officers, who will fight the ships, to decide. It is easy to understand how a naval constructor may go in a direction quite contrary to that of Admiral Hichborn, and be carried a little too far in his estimate of the value of speed, for in times of peace it is often the only quality—putting aside, of course, price—by which the general public judge of the success of a warship. Nevertheless, experience has shown that speed has a high fighting value in steamship actions.

What boilers are actually to be put in the different ships by various builders we are not aware. They are, however, to be of the water-tube type.—*Engineering.*

THE HAMBURG-AMERICAN ATLANTIC LINER DEUTSCHLAND.

This vessel has been built by the Stettiner Maschinenbau Actien-Gesellschaft Vulcan, at Bredow, near Stettin, where also the North German Lloyd steamer Kaiser Wilhelm der Grosse was constructed and engined. The latter has attained a speed on the Atlantic of 22½ knots, and has thus excelled all previous performances; and the new ship is expected to make 23 knots in service, and is equipped with engines to develop 33,000 indicated horse-power, the greatest power fitted in any ship up to the present time. The fastest of our British Atlantic liners are the Campania and Lucania, and they have a displacement tonnage of about 17,000 tons, their length between perpendiculars being 600 feet; the Kaiser Wilhelm der Grosse is 625 feet long and of 19,800 tons displacement; and the Deutschland 662 feet 9 inches long and 23,000 tons displacement. The British ship may be put at quite 22-knot speed, and it is interesting to note that the power has not increased at the ratio one would expect in view of displacement and speed, a fact due probably to the greater length of the hull. The Deutschland is to leave on the first voyage to New York on June 17, and her performance will be watched with interest. In this connection it may be noted that she is to leave Hamburg every three weeks instead of every fourth week, as has been the case with the Atlantic liners hitherto. This practice has also been adopted by the

American line, and secures the advantage of a greater amount of work from the ship within a given time, experience having shown that those high-speed liners are, as a rule, superseded by faster boats before they have done a full share of work.

The Deutschland is 662 feet 9 inches long between perpendiculars and 686 feet over all, 38 feet longer than the Kaiser William der Grosse. Her beam is 67 feet, 1 foot more, and moulded depth 44 feet, also 1 foot greater. The gross tonnage is 16,000, and the displacement 23,000 tons.

The machinery differs from the Kaiser Wilhelm der Grosse, which has four-cylinder, triple-expansion engines; the Deutschland has six-cylinder, quadruple-expansion engines, and thus, notwithstanding the increase of power and quadrupling, the low-pressure cylinders are only 106.3 inches, not by any means a maximum, as compared with 96.4 inches. The two low-pressure cylinders are in the center, with the two high-pressure cylinders over them, and at the forward end is the first intermediate and at the after end the second intermediate. The two first cranks, set opposite each other, have thus the intermediate in the one case, and a high-pressure and low-pressure cylinder in the other, and the after pair of cranks, a high pressure and a low pressure in the one case, and the intermediate on the other crank. The cylinders are placed close together, the valves being on the outside, and there is a separate valve gear for each cylinder, *i. e.*, six sets for the six cylinders of each engine. The end cylinders have their valve boxes on the outside, and owing to the great diameter there are two spindles, a system adopted in the Kaiser Wilhelm der Grosse. The diameters of the cylinders are as follow:

Two high-pressure cylinders	30.6 in.
One intermediate-pressure cylinder (I.)	73.6 "
One intermediate-pressure cylinder (II.)	103.9 "
Two low-pressure cylinders	106.3 "
Common stroke	72.8 "

Together the engines are to indicate 33,000 horse-power, when running at about 76 revolutions per minute. The cooling surface of the two surface condensers total 42,630 square feet.

There are twelve double-ended and four single-ended boilers, divided equally into four sets for four boiler compartments.—*Engineering.*

SUBMARINE BOATS.

Interest has again been revived in the subject of submarine boats, owing to the report that France has decided upon the construction of a large fleet, 100 being given as the number, while the United States navy authorities have come at last to the conclusion to purchase the Holland boat after many trials. This uncertainty of opinion is shared by all governments, excepting only that of France, in which country the conditions of a naval war are such as to justify the undertaking of the risks more or less inseparable from the submersibility of such craft.

Although it would not be quite accurate to say that there has not been advancement towards the solution of the inherent difficulties to submarine navigation, a glance at the successive experiments is not by any means encouraging.

The first submarine boat did not drown anybody; but whether or not the great Cornelis van Drebbel actually submerged the boat which he exhibited before James I. on the Thames in 1624, is not quite clear. Day

did go down at Yarmouth in 1660, and when he repeated his experiment, boat and crew failed to reappear. Fulton was more successful: he kept four hours under water in 1801, and exploded a mine at Brest from his boat. Phillips' wooden boat was crushed by the water pressure on Lake Erie, and the same fate befell Bauer's iron boat in 1850 at Kiel; he and his two men had a marvellous escape, being carried by the huge compressed air-bubble. The boat of McClintock and Howgate, constructed in 1863 for the Confederates in the American civil war, sank four times, and each time killed its volunteer crew, 32 men in all. All these craft had less than 30 tons displacement, employed water ballast and manual propelling power, and resembled plumply-built fish in their shape.

With the same year, 1863, began the days of the cigar-shaped boats of considerably larger tonnage, fitted with steam, pneumatic, petroleum, or electric power, and sometimes with two separate sets of motors, for motion on the surface and under water. Noteworthy among these are Nordenfelt's four boats, which burned fuel when on the surface, and relied on the heat stored in the boiler when under water. During the last fifteen years another type has come to the front: boats which keep just under the water-line, and which are to dive under only in extreme cases. To this class belong the boats of Hovgaard, of Peral, and the several craft which Admiral Aube had constructed: the two boats of Goubet, Zédé's Gymnote, and the Gustave Zédé. France has been most persevering in these endeavors. Last summer, Romazotti's Morse was launched at Cherbourg; she is to have two sisters, the Français, and the Algérien; and there is finally Laubert's Narval, also launched at Cherbourg in October last, fitted with petroleum and electric motors and accumulators, whilst the other French boats mentioned depend entirely upon accumulators. Giorli's boat of 1893 is distinguished by three horizontal rudders, one of which is automatically adjusted by a pendulum. Finally, there are the six Holland boats, the last of which is entirely of Mr. Holland's own design.

The flooded boats, which keep awash, just under the water surface, look like torpedo-boats. They are spacious enough not to need any compressed air stores for breathing; and the tube projecting above the water-level, provided with a mirror at an angle of 45 deg., is a help to the man at the helm—not much of a help, though, for the elevation is too small to give a proper field of view. In stability these craft are superior to the totally submerged boats, but they suffer from many of the drawbacks of submarine boats which are regarded as serious, notably by such an expert as Professor Busley. He is acting president of the newly formed Schiffbautechnische Gesellschaft, a German naval constructors' institution whose inauguration recently was attended with so much *éclat*, due to the presence of the German Emperor to hear the professor's contribution on this important subject of submarine boats.

Amongst those serious inherent difficulties, Professor Busley places first the low stability of submarine boats. Some people still seem to forget that the displacement center of gravity of a totally submerged boat is simply the mass center of the water displaced, and does not alter its position whatever inclination the boat may assume. There is no buoyancy. Yet transverse stability and prevention of rolling, are not so difficult to obtain, provided the section of the boat is like that of an egg, poised on its point. If we use ballast, the center of gravity of the system will be low down, and the displacement center high up. The low longitudinal

stability, the tendency to pitching, is the trouble. A man need only step forward to send the nose of the boat down. For this reason the Plongeur of Bourgeois failed, and the length of boats has been reduced again. Goubet has gone furthest in this direction, and his two men always sit in the middle of the boat. Bauer tried to apply counterpoises, Holland automatic pumps, to restore longitudinal equilibrium. Nordenfelt did not deprive his boat of all buoyancy and counteracted its effect by a submerging propeller. The flooded boats are better off in this respect. But even in their case we notice a reduction in length; the Zédé had a length of 45 meters, the Morse of 36 meters, the Narval of 34 meters. It has, on the other hand, been pointed out that they are not good seagoing boats, hardly fit for rough weather; and their own designers have proposed to give them a little freeboard. If we do that, we lose the chief advantage of the submarine boat, the immunity against projectiles; and we may argue whether we had not better return to ordinary boats, in which we are not tied down to small space and small speed, and all sorts of undesirable conditions.

Submarine boats remain dangerous to manage. On the average, perhaps, we may construct them strong enough to descend to a depth of 100 feet. Supposing a boat, moving at the usual speed under water, 8 knots, is to discharge a torpedo. Two men are sent forward; the boat at once inclines 15 deg., and within half a minute it will have arrived in its critical depth. If there is any delay or any fault in the steering gear or in the application of safety weights, etc., every second will seriously increase the pressure of the water outside. Trials made with the Gymnote, moreover, indicate that submarine boats do not obey their horizontal helms with sufficient rapidity. The Gymnote always overshot her mark, and would not keep on a straight course, but described a succession of curves. Professor Busley tried to pull a submarine boat under water; it could not be done when the speed exceeded 4 knots. That all operations near the coast or in shallow water are exceedingly dangerous, need not be emphasized. Campbell's boat managed to wriggle herself out of the Thames mud again in 1886; the accident testified to the nerve and skill of Lord Charles Beresford, and also to his good luck.

These dangers are increased by the exceedingly limited range of sight under water. Light emanating from a focus under water will, at a distance of 100 yards, not have the ten-millionth part of its intensity; and not much of the daylight penetrates into the water as it is. On a clear day, a diver 20 feet below the surface, is hardly able to see further than 25 feet. Searchlights would be of little good, and would, moreover, betray the position of the craft. Hence the boat must approach the ship it wishes to attack very closely; and if the ship is moving, the case is almost hopeless. So far, we hardly know of submarine boats doing more than 8 knots. The slow speed is largely due to the weight of the batteries, which for a journey of five or six hours would weigh about 6 cwt. per indicated horse-power; and we appear as far as ever removed from materially diminishing the weight of electric accumulators.

This low speed, and the short period during which such a boat can be kept in motion without replenishing its charge, limit the range of action of the submarine boats badly. The Gymnote could make a run of 45 miles at 10 knots, it has been said; most submarine boats have not accomplished so much as that. The submarine boat thus can merely be utilized for the defense of a port, and it is a very expensive means of

defense. The Narval is stated to have cost about 30,000*l*. Adding a third to this sum, we could construct a torpedo-boat destroyer of four-fold speed and three-fold displacement which may achieve something. Whether a submarine boat would ever escape from a successful attack is a very doubtful question. Professor Busley does not dwell upon that point. But if the boat almost has to feel its way up to the object of attack, because it cannot see to any distance, the chances of escape are decidedly poor.—*Engineering.*

AMERICAN FREIGHT LOCOMOTIVES AND THE ENGINES OF THE OCEANIC—A COMPARISON OF HORSE-POWER.

We are told that "comparisons are odious," and the statement would seem to be based upon a fairly correct estimate of human nature; but as soon as we get outside of the range of human susceptibilities and apply our comparisons to insensate things, comparisons become not only extremely interesting, but at times a valuable means of increasing our general knowledge and our sense of the proper relative proportion of things.

In addition to the usual information as to dimensions and construction, Mr. R. Wells, the superintendent of the Rogers Locomotive Works, has favored us with particulars of some novel experiments which he carried out to determine the exact location of the center of gravity of this locomotive above the rails. He has also given us particulars of its horse-power and freight-hauling capacity on a level road, and it occurs to us that a comparison of the relative power of one of these engines when working up to its maximum indicated horse-power with the maximum indicated horse-power of the Oceanic, the largest steamship in the world, will be attractive to that section of our readers that likes to have its facts enlivened occasionally with a touch of the fanciful and curious.

The locomotive was designed to haul trains of a maximum weight of 2000 tons over grades of 38 feet to the mile. The cylinders are 23 inches in diameter, by 30 inches stroke; the drivers are 57 inches in diameter and they carry 198,000 pounds weight of the locomotive out of a total weight of 218,000 pounds. The boiler, which is of the Belpaire type, is 80 inches in diameter at the smoke-box; the fire-box measures 42 inches by 132 inches, and there are 417 2-inch tubes which are 13 feet 8 inches in length. There are 252 square feet of heating surface in the fire-box, and 2951 square feet in the tubes, making a total heating surface of 3203 square feet. The tender is exceptionally large, the capacity of the tank being 5000 gallons, while the coal space has a capacity of 10 tons.

The increase in the diameter of locomotive boilers which has taken place of late years has necessitated their being carried above the tops of the wheels, with the result that the center of the boiler is in some recent locomotives as much as 9 feet above the rails. To the uninitiated these immense machines have an exceedingly top-heavy appearance, and it looks as though their stability would be endangered, especially when they are running at high speed around a curve. Before sending this engine out of the shops, the Rogers Locomotive Company made an experimental test to determine the exact location of its center of gravity. The result is certainly surprising, for although the top of the boiler is

fully 9 feet above the rails, the center of gravity was found to be only 50½ inches above the top of the rails, that is to say, about 6½ inches below the top of the driving wheels. As a matter of fact, the great bulk of the boiler is very deceptive to the eye, and one is liable to forget that the greatest concentration of weight lies in the heavy frame, the wheels, the axles, cranks and running gear, and the heavy saddle and cylinder castings. The test was made by suspending the engine on the upper surface of two 3-inch steel pins or journals as pivots, the one at the front being located 6 inches in front of the cylinder saddle, and the one at the rear, 6 inches back of the boiler, both pivots being, of course, the same distance above the rails and on the vertical center line of the engine. After several trials, points of suspension were found which were in line with the center of gravity, which, as thus determined, was found to be 50½ inches above the top of the rail. As the bearing points of the drivers on the rails are about 56 inches apart, the base on which the engine runs must be 1.1 times as wide as the height of the center of gravity of the engine above the rails. It is evident from this test that the center of gravity of such a locomotive could be raised still higher without endangering the stability of the engine under the ordinary conditions of service.

A COMPARISON OF MARINE-ENGINE AND LOCOMOTIVE HORSE-POWER.

In order to secure a basis for comparison of the power of a modern freight locomotive with that of a modern steamship, we have chosen the greatest vessel of them all, the Oceanic. This truly gigantic ship, which exceeds the Great Eastern in length and in displacement, is 704 feet in length, and on a draft of 32½ feet displaces 28,500 tons. As the depth of water in the entrance channels to New York harbor will not accommodate a vessel drawing that amount, for the purpose of this comparison we will suppose that the Oceanic is drawing 30 feet, at which draft she would displace about 26,000 tons. On this displacement her engines will indicate about 28,000 horse-power when driving the vessel at a speed of 22 land-miles an hour.

Now, it is estimated that the big Rogers Consolidation could haul about 3250 tons weight of train at a speed of 22 miles an hour, on the level, and that while doing this work it would indicate about 1760 horse-power. Here then we have a basis of comparison, and we may apply it in two ways. Either we may ask how many of these locomotives would have to be crowded into the hold of the Oceanic, and coupled to her main shafts, in order to drive her through the water at 22 miles an hour, or we may determine how many of these locomotives it would take to haul the Oceanic if she were placed upon a movable cradle of the kind designed by Captain Eads for his Tehuantepec Ship Railway. In the first case, we know that when the main shafts of the Oceanic are making about 90 turns a minute, the engines are indicating about 28,000 horse-power, which is their maximum capacity. On the other hand, we know that when the drivers of one of these locomotives are making about 150 turns a minute, and the maximum tractive effort is being exerted at the periphery of the wheels, it is indicating about 1760 horse-power, which represents its possible maximum indication at that speed. If now the sixteen necessary locomotives (the number being found by dividing the horse-power of the ship by the horse-power of the locomotive) were arranged in two lines, one above each main shaft, and the tractive effort of the drivers transmitted by means of friction wheels to the shafts, the

speed of the rotation being reduced by intermediate gearing, in the ratio of 150 to 90, we should have the conditions required.—*Scientific American.*

STEAM ELECTRIC LIGHTSHIP FOR CAPE HATTERAS.

A few miles off the shore of Cape Hatteras are the justly dreaded Diamond Shoals, on which futile attempts have been made to erect a lighthouse. Something over a decade ago the contract was let to a large and experienced contracting firm in this city for the sinking of a huge caisson into the sandy bed of the shore upon which to carry the proposed structure. The caisson, however, was wrecked and the failure seems to have discouraged any further effort. It would seem as though the only practicable way to protect shipping is to moor a lightship above the shoals and this has been attempted. The last vessel to be placed there was recently torn from its moorings during a heavy gale, and it became evident that a ship of special design was necessary to meet the exceedingly trying local conditions. Such a vessel has been designed and is now nearing completion at the yards of the Fore River Engine Company, of Massachusetts. She will be steam-propelled and electric-lighted, and when completed she will be one of the first, if not the only one, of her kind ever launched. The government contract calls for a vesssel 112 feet between perpendiculars, with a molded beam of 28 feet 6 inches, and a depth of 14 feet 10½ inches measured from the main deck beams to the top of the keel amidships.

The vessel will have three decks, the main and spar decks running full length of the ship, while the lower deck is broken by the forward coal-bunker and the after bulkhead of the engine-room. The hull will be divided by water-tight steel bulkheads into five compartments, and the quarters and storerooms are so arranged as to meet all requirements of safety and comfort. The dynamos and engines for the electric-light plant will be located on the main deck, as shown, and within the engine and boiler casing. The accommodations for the crew are forward on the main deck. There will be two hollow steel masts, through which the wiring for the masthead flashlights is to run. These lights, three in number on each mast, are to be adapted for electricity or for oil lamps. The cluster mast headlights will be 59 feet above the water-line, the measurement being taken from the 12-foot water-line to the focus of the lamps.

The electric plant will be driven by two non-condensing, double-cylinder engines, running under a steam pressure of 80 pounds to the square inch. The vessel will be lighted by eighty 16-candle-power 100-volt lamps, which will be placed where necessary throughout the ship. The mast-head cluster will consist of six 100-candle-power 100-volt lamps, and these lights will be controlled by an automatic flashing device. It is driven by means of a belt from the dynamo shaft, and a worm and worm-wheel which serve to give the proper rotary speed to a circuit-breaker. The lightship will be propelled by an inverted, surface-condensing, single-cylinder engine of 250 indicated horse-power, with a cylinder 23 inches in diameter by 22-inch stroke, driving a cast-iron propeller 7 feet 3 inches in diameter. Steam will be supplied by two straight, cylindrical, tubular boilers, 9 feet by 16 feet 7½ inches, with a working pressure of 100 pounds to the square inch. The deck fittings of the vessel are flush, with

a view to presenting as little surface as possible to the action of wind and water.

When No. 72 is on her station off the treacherous Hatteras shoals her mooring tackle will consist of a heavy mushroom anchor, shackled to a chain which leads through the main hawser hole in the stem of the ship to a steam windlass. In addition to this mooring tackle, the vessel will have a 2000-pound harbor anchor, a kedge weighing 340 pounds and 120 fathoms of 1⅛-inch stud-link chain, with a breaking strength of 79,100 pounds. Amidships, on either beam, will be swung two whale-boats of about 26 feet length and 6 feet beam.

The spar deck is protected by a gradually rising steel waist, which starts flush a little forward of abreast the foremast, flaring somewhat at the knightheads until at the stem proper it has a depth of 5 feet. In addition to the steam whistle, the lightship is provided with a steam siren which is fitted just forward of the smokestack for use in thick and foggy weather.—*Scientific American.*

THE IMPERIAL JAPANESE BATTLESHIP ASAHI.

Although she differs considerably from the Shikishima in appearance, the Asahi is practically a sister ship, the sole points of difference being (1) funnels; (2) distribution of the 2½-pounders; (3) absence of a bow torpedo-tube; and (4) mounting of the big guns. There are, of course, certain minor structural differences—such, for instance, as the fact that the Asahi has a slightly larger ward-room, and that this ward-room is a trifle further aft—but, generally speaking, for fighting purposes they are identical save for the points of difference noted above. There are unseen differences of detail also, such as the thickness of the armor deck, but none of these affect the fighting value. There is a difference, too, in the coal carried, but coal capacity does not show to the eye.

The details of the Asahi, with those of the Shikishima and the British Formidable, are as follows:

	Asahi.	Shikishima.	Formidable.
Displacement	15,200	14,850	15,000
Material of hull	steel	steel	steel
Length, feet	400	400	400
Beam, feet	75¼	75⅝	75
Draft, feet	27½	27½	26½
Guns—12 in.	Four 12 in. Mark IX. for all		
6 in.	14	14	12
3 in.	20	20	16
Smaller	6 3-pdr. 6 2½-pdr. 8 Maxims	6 3-pdr. 6 2½-pdr. 8 Maxims	12 3-pdr. 8 Maxims
Torpedo tubes, submerged	4	4	4
Torpedo tubes, above water	0	1	0
Armor belt, inches	9	9	9
" at ends, inches	4½	4½	3
" deck, inches	4	5	3
Lower deck, inches	6	6	9
Casemates, inches	6	6	6
Barbettes, inches	14	14	12
Bulkheads, inches	14	14	12
Armor material	Harvey nickel, all three		
I. H. P., forced	15,000	14,500	15,000
Boilers	Belleville, all three		
Speed (contract)	18	18.5	18
Coal (normal)	(?) 1,400	700	900
Screws	Two in all three		

There is some doubt about the Asahi's coal, 1400 tons may be the maximum and 700 the normal. Japanese ships do not need to carry much coal, being designed to operate in waters where friendly coal stations are numerous. True, ships thus kept short are likely to be out of action because they are coaling, about once a week, but on the other hand, as they get two extra 6-inch quick-firers, and four 12-pounders for this sacrifice, they are rather envied by our naval officers. After all, the primary duty of a battleship is to hit the enemy hard, and an extra 6-inch in the broadside is no mean advantage. There are other incidental advantages too—a single 6-inch shell would put all the eight 12-pounders out of action on the upper deck of the Formidable, while, thanks to the casemates acting as screens, the Asahi could only lose two of her 3-inch by a single shell. In the placing of her 3-inch guns she is altogether better off than the Formidable, as a comparison of the plans will indicate, the sole point in which the British ship is better off being the four guns carried on the main deck forward. The Formidable can fight all these on the broadsides, it is doubtful if the Asahi could, because of the blast from the big guns firing above them. But *per contra* she has her other 3-inch quick-firers much better placed; they are more distributed. The positions of these are: Four on the main deck forward; four on the main deck aft; four on the upper deck amidships; two on top of the forward upper deck casemates; two beside the fore conning-tower; and four beside the after conning-tower; a total of twenty. Those of the Shikishima are placed in exactly the same fashion. Those of the Formidable are: Four on main deck forward (extreme bow); four on main deck aft; and eight on upper deck amidships; a total of sixteen. Three units instead of six; or, to put it another way, work for only three shells instead of six shells. The Asahi is an improvement on the Shikishima in the matter of the 2½-pounders, a very small detail. In the Shikishima these are grouped on top of the amidship upper casemates; in the Asahi only two are over these casemates, the other four being distributed, a couple on each bridge. Two theories are at work here, and it will need a war to say which is the better. In the Shikishima it is easy to concentrate three 2½-pounders on a single torpedo-boat or portion of a big enemy, while, as a price for this, they are at the mercy of a single shell. Those of the Asahi are not thus at the mercy of one shell, but it will be far less easy to concentrate them.

The next point of difference between the Shikishima and the Asahi is that the former carries a bow above-water torpedo-tube, with 6-inch Harvey nickel protection to it. This tube, similarly protected, is in the Fuji, Yashima, Asama, Tokiwa and Yakumo. After some experiments and practice the Japanese authorities decided that this tube was of no use practically, and decreed its abolition. That of the Shikishima had, however, already been built in, so this ship has it. It is absent also on the Hatsuse, a sister, and in the Iwate and Idzumo.

Under certain circumstances such a tube might be of great use in action; for instance, approaching an enemy who presented his broadside while the ship possessing the tube wished to make a feint to ram. But to use it, it would be necessary to slow down or reverse engines—both things that might be awkward to do in an action. Still the real objection does not lie there, so much as in the trouble with sea that a bow tube causes. Bow guns, even high up, are always liable to get "washed out," a bow

torpedo-tube is still more likely to be so. In addition to this, it raises an unnecessarily large bow wave.

In comparison with the Formidable, the Asahi and Shikishima have, beside the 6-inch and 3-inch guns, other points of distinct difference. They have: (1) Complete instead of partial belts; (2) 6-inch instead of 9-inch armor protecting the lower deck; (3) much higher barbettes; and (4) quite differently shaped hoods to the big guns.

Of these differences the armor one is of no immediate moment at present. The Asahi, in the matter of armor, is practically a Majestic with 3 inches stripped off the lower deck amidships and disposed on the ends plus some extra armor paid for in the weight of coal carried. Now, the 6-inch lower deck armor of the Asahi is proof against any 6-inch projectile at any range; and though a steel-pointed 9.2-inch common shell has been through 6-inch Harvey nickel at Whale Island, this is probably an isolated proving-ground case, and nothing but an armor-piercing shell of large caliber is ever likely to get through such armor in actual warfare; and it is at least doubtful whether such a shell would do more harm than a solid shot, and against a 12-inch solid shot 9-inch armor is no more protection than 6-inch. In either case the shot will go through and dance about inside, and it is this "dancing about" that makes shot dangerous, and all armor save the very best a snare and a delusion so far as solid projectiles are concerned. However, medium armor is imperatively needed to keep off shells, for it is good-bye to any ship inside of which a big common shell is comfortably planted. The Admiral class, for instance, would do no more fighting once a big common shell got them amidships.

As for the complete belt, the Formidable, of course, has something on the bow, and this may be considered proof against 6-inch shell in action, save at short range. It is, at any rate, proof against the deadly little shell from 12-pounders and the like. As for any 6-inch shot—well, very few 6-inch shot are carried in any ship, and holes made by them are easily plugged.

The real gain of the Asahi is the extra gun power, but since it is held essential that British ships shall have a large coal supply, it is useless to decry the Formidable over the two missing 6-inch guns. The defect of the Formidable, and one that might have been remedied, is the position of the 12-pounders. These could and should have been either more distributed, or else placed right up above everything and clear of everything, much as the French place their 4-inch quick-firers. Such a gun is extremely unlikely to be actually hit, whereas if it is crowded about with bulwarks, boats, and so on, a shell coming anywhere near is bound to burst with devastating effect.

In appearance it is difficult to tell the Asahi from our Canopus class, save for color. A critical eye could detect the much higher barbettes of the Japanese vessel and their different shape, but that is about all, for the extra casemate would hardly be visible at any appreciable distance. Like the Canopus class, the Asahi has the huge after funnel, and the resemblance is increased by the tautness of her masts. The sign manual of a British man-of-war is the rake forward of the top masts, in the smartest Channel fleet ships this is most noticeable; but the Asahi also is taut.

The Asahi has a slight sheer forward, like all our new ships, in consequence of which, though both pairs of guns are at the same height above the water, the after barbette looks a good deal higher than the fore one.

The shields are peculiar—sloping fronts but straight sides. The British pattern slopes all round, and is generally more squat, and of the two is more favorably regarded afloat. If by any off-chance a big shot hit the side of the Asahi shield it would get through, from the inclined sides of the British pattern it would rebound at any range. However, a shot is very unlikely to hit the sides of the shield, and probably the mere shock of a big projectile would effectually displace everything and put the turret out of action. Wherever a big projectile hits it must do some harm, whether it gets through or not, and the old American idea of battering in preference to penetration is not so unsound as many folk are now disposed to regard it. Especially must this be so with certain foreign-built ships—the least little thing wrong and the colossal blow will find it out.

The guns and mountings of the Asahi are from Elswick. They embody some slight improvements upon those of the Shikishima, but are on exactly the same general principle. The 12-inch can easily do a round a minute, and should be able to do a round every two minutes in action. The rate of the 12.5-inch Canet gun at Yalu was one round per sixty minutes, but there were special circumstances involved. Still there is no doubt that big guns have made enormous strides towards quick-fire in the last year or two, and two of the Asahi or Formidable 12-inch are equal to three of those in the Majestic probably.

The Asahi is fitted with the Barr and Stroud transmitters, each case-mate having an indicator, in English and Japanese, to give the range automatically from the conning-tower. The official British view is against these transmitters, on the ground that action will derange them; but there is no getting away from the fact that, even so, till deranged they will be exceedingly useful. Our methods of passing the range are cumbersome, and, in addition, by the time it is passed it has probably altered. Moreover, gunnery is not so much a matter of good shooting as knowing the range; the wrong range given accounts for most misses, at any rate in the British navy.

All the hoists in the Asahi are electrical, with auxiliary hand-power in case of need.—*The Engineer.*

JAPANESE TORPEDO-BOAT DESTROYERS.

Length, 210 feet; beam, 19 feet 6 inches; draft, 7 feet; engines, 5700 I. H. P.; speed, 30 knots.

Six of these vessels are of steel throughout, building at Thornycroft's Works.

The propelling machinery consists of two complete sets of engines of the type invented and patented by Mr. Thornycroft, driving twin-screw propellers, each set having one high-pressure, one intermediate and two low-pressure cylinders, supported on steel columns somewhat out of the perpendicular, and so arranged that the thrusts of the rods simultaneously act on the cranks from opposite directions, in order to obviate vibration in working. In addition to the propelling machinery with condensers, circulating pumps and engines, air and feed pumps, there are fitted the blowing engines, steam steering engine, air-compressing machinery, electric-light machinery, and distilling machinery. Three of Mr. Thornycroft's patent water-tube boilers are fitted in each vessel, which give ample steam, and are remarkably efficient in respect of its rapid generation.

These boilers are fitted respectively with automatic feed regulating gear, which regulates the supply of feed water (a steel float fitted in the upper barrel of the boiler automatically opening or closing the valve through which the boiler is filled). Each boiler is capable of being worked independently, and adapted for a working pressure of 220 pounds per square inch. The armament of each vessel consists of one 12-pounder 40-caliber quick-firing gun, and five 57-millimeter quick-firing guns, also torpedo gear, consisting of two revolving tubes placed on deck aft, arranged for discharging 18-inch Whitehead torpedoes.

The full complement of each vessel of all ranks is 54 men, and the accommodation provided for them is: One commander's cabin, one wardroom, two petty officers' cabins, three compartments for crew.

The six Yarrow boats are 10 feet longer, 1 foot more beam, and about 1 knot more speed than the above.—*Engineering.*

JAPANESE FIRST-CLASS TORPEDO-BOATS.

The Japanese government, having determined to increase their torpedo-boat flotilla, after considering the various designs submitted, decided upon adopting the one proposed by Yarrow & Co., Limited, and they placed an order for 10 first-class torpedo-boats with this firm last year. These vessels are 152 feet 6 inches in length by 15 feet 3 inches beam. They are single-screw boats. The contract speed is "not less than 27 knots with a 20-ton load," and a probable speed of 25 knots with the full load of 44 tons.

The vessels are built of mild steel, each being divided into ten compartments, which compartments are devoted to the machinery and crew space, as customary in this class of vessel, there now being little difference in the system adopted by various naval powers as regards the distribution of the load. The turtle deck extends from the bow for some length aft.

There are two boilers of the Yarrow straight-tube type, designed for a working pressure of 220 pounds per square inch, and capable of supplying steam for 2000 indicated horse-power, with an air pressure in the stokehold of about 1¼ inches. The main propelling engines are of the three-cylinder, triple-expansion type, balanced on the Yarrow system, to minimize the vibration. The cylinders are 18 inches, 26 inches and 39½ inches in diameter, with a stroke of 18 inches, and designed to run up to 400 revolutions per minute.

The vessels are lighted throughout by electricity.

The coal-bunkers hold 32 tons, which is sufficient to take a vessel of this size across the Atlantic, two sister ships having navigated from London to Valparaiso.

The armament consists of one 14-inch Whitehead torpedo-tube built into the bow above the water; one revolving torpedo-tube on deck, about one-third of the length of the vessel aft of the stem. This tube revolves about an axis in the middle line of the boat, so that the tube can be discharged over either side. A similar 14-inch torpedo-tube is provided aft. There is a water-tight torpedo-room under the forward crew space suitable for carrying three reserve torpedo bodies, the warheads being stowed in a separate magazine. The reserve torpedoes are lifted either direct to the bow tube or transferred on a small trolley along a tramway on the deck arranged in such a way that the torpedo can be

placed in either of the central tubes. There is a 2½-pounder quick-firing gun right aft with an almost all-round radius of fire.

The searchlight is placed on the conning-tower.

Although the armament above described was adopted after careful consideration by the Japanese authorities, it is by no means the limit for a vessel of this class, a much heavier armament having been carried on five similar boats recently constructed by Messrs. Yarrow & Co., for the Austrian navy, *i. e.*, two 18-inch Whitehead torpedo-tubes, one on each gunwale abaft the conning-tower forward, and one 18-inch torpedo-tube aft, two reserve torpedoes in the torpedo-room, and two 47-millimeter quick-firing guns, one on each side of the conning-tower.—*Engineering.*

There was launched on March 29, from the Elswick Shipyard of Sir W. G. Armstrong, Whitworth & Co., the Japanese first-class armored cruiser Iwate. The Iwate is a sister ship of the Asama, which was launched from the same yard some time ago. The principal dimensions of the vessel are: Length between perpendiculars, 400 feet; breadth, 68 feet 6 inches; depth, 41 feet; draft, 24 feet 3 inches; displacement, 9750 tons. The armament consists of four 8-inch breech-loading guns twin mounted in barbettes; fourteen 6-inch quick-firing guns in 10-inch casemates, six on the main deck and four on the upper deck, the remaining four being on the upper deck protected by shields; twelve 12-pounder quick-firing guns; and eight 2½-pounder quick-firing guns. There are four submerged torpedo-tubes, two forward and two aft. The vessel has a complete water-line belt of Harveyed nickel-steel armor, 7 inches thick, amidships and reduced at the ends. Above this there is a citadel of 5-inch Harveyed nickel-steel armor enclosing the bases of the barbettes and carried from the top of the water-line belt to the main deck. The barbettes are of Harveyed nickel-steel 6 inches thick. The casemates are of nickel-steel 6 inches thick. The conning-tower is Harveyed nickel-steel 14 inches thick. The machinery is of the twin-screw vertical triple-expansion type, and is to develop 14,500 indicated horse-power. The speed guaranteed is 20¾ knots, and the boilers are of the Belleville latest type. The vessel has a bunker capacity for about 1600 tons of coal. Accommodation is provided for an admiral, 52 officers, and 430 petty officers and men.—*Engineering.*

SHIPS' ARMOR.

Lord Hopetoun says that two courses are open to the government. "Either to extend by means of orders guaranteed over a series of years, the number of firms capable of supplying armor-plate; or for the state itself to undertake its manufacture." He goes on to say that "the latter course is open to serious objections," an opinion to which nearly all who have studied the subject will subscribe; and we think that had Lord Hopetoun realized how very serious the objections are, he would hardly have put forward the proposal of a state armor factory, even as a remotely possible alternative; so long, that is, as there are private makers willing to lay down the plant needed for any possible need of the fleet.

Our Admiralty investigated this question of state supply many years ago and decided in favor of private manufacture.

It will be interesting to look abroad and see what has been done in countries where the possibilities of private supply are far below our own. The question was well considered in the United States three or four years ago; for, as is well known, the American government authorities have had a good deal of trouble in getting their armor supplies, and, indeed, recently came to a complete deadlock.

In the official report of the Chief of the (United States) Bureau of Ordnance for 1897, the question is dealt with very completely, and the opinion is definitely expressed "that the (United States) government can purchase armor more cheaply than it can manufacture it." The Ordnance Bureau rightly regarded "the making of armor as a proper adjunct to a great commercial steel plant. . . . Should the department acquire a plant of its own, the chances are that it would be at a great cost, and that it would lie idle a large part of the time, and thus suffer deterioration, and that the expense and difficulty of operating it when needed would more than offset any advantage gained by such ownership."

In a publicataion issued by the American Iron and Steel Association, it is stated that "every naval power of Europe has, at different periods since the advent of the armor-clad ship, contemplated government manufacture of armor. The government factory erected by the Russian government near St. Petersburg is, we believe, the only establishment of the kind belonging to any naval power. The plant is said to be still incomplete, and has cost from four to five millions sterling. It is conceded that armor can never be made there at as low a price as it could be purchased from abroad; a statement no one will be likely to question." The measure was, however, but a part of a policy that the Russians have always pursued; namely, to make the nation as self-contained as possible in regard to warlike supplies. As a matter of fact, the Russians are still large customers to foreign armor-plate makers, the American makers having profited largely by their custom, and the vast expense of the Kolpino factory is excused on the score of it being a reserve establishment to be brought into play upon the outbreak of war when foreign supplies might be cut off. The explanation is somewhat lame. The nation that trusts to laying down ships and making armor when war has been declared, would be pursuing a course far more foolish than the shrewd Russians are likely to contemplate. The real point of interest for us at present is whether the Russians might not have better encouraged home industry and strengthened the military resources of the country more effectually at the same time by spending an equivalent, or a far smaller sum, in guaranteeing a continuance of orders to private firms.

Some interesting figures relating to the assumed cost of an armor-plate factory were given in a letter of the Secretary of the United States Navy in 1897, quoting the opinion of the Chief of the Bureau of Ordnance. The sum of 300,000*l.* had been estimated as the price of a plant needed for the purpose. This is described as "quite inadequate"; and the obvious fact is pointed out that a plant for armor-making must comprise a steel-making equipment also. To obtain the necessary stock of material for working on a large scale, and for the unavoidable experimental work in the beginning, 600,000*l.* would be required. The Carnegie armor plant was at that time said to have cost that amount, and it has increased since then.

This country, however, stands on quite a different basis to either the

United States or Russia, but whatever arguments are to be advanced in favor of private manufacture with those, or, indeed, any other nations, are of considerably more weight in regard to Great Britain. We are far from agreeing with those perhaps somewhat short-sighted enthusiasts who say "the navy must have the very best of everything, no matter what it cost"; for cost is necessarily a very ruling factor, not only in a naval programme, but in the design of ships. In this case, however, cost is a minor consideration, and if private makers were not to be trusted to make the best kind of armor, we would be prepared to advocate considerable pecuniary sacrifice. There is, however, hardly a shadow of doubt that the result would be quite in the opposite direction. No doubt a government factory would produce in a leisurely manner excellent armor of ten or fifteen years' antiquity, and we should see the private firms of the country supplying plates for foreign ships that would be far more resistant to shot and shell than those being placed on the sides of the ships of the Royal navy.

We say we should see our private firms supplying armor to foreign powers, but the statement needs perhaps some consideration. Some of the foreign powers are making very rapid strides not only in armor-plate making, but in other branches of steel manufacture. England once held the palm in this field both for inventive ingenuity and boldness in carrying inventions to a practical issue. That former activity has placed us in the position we yet occupy in this field. But we are, it must be confessed, somewhat trading on the past, and no longer hold our old undisputed supremacy. Compound armor was an English invention; it inaugurated the principle upon which all modern armor is made, of a hard and, therefore, comparatively brittle face to resist penetration, in conjunction with a tough and softer backing to hold the mass together and prevent breaking up. Since then, however, further advances have been due to the inventors of other countries, and our armor-plate firms have been dependent on their labors. The Harvey process came to us from America, and now we have the further improvement introduced by Krupp.

It may be said that this being the case, there is little reason for encouraging the private firms. They have not made advances, therefore a government department could not be more stationary; for, of course, no one expects government factories to inaugurate improvement. That would be mortgaging the future, and, as a matter of fact, the English makers have made improvements, though they have not of late effected a quite new departure. But, beyond this, that notable advances have been made abroad is a very cogent reason why a government factory should not be trusted with the supply of armor. Governments are influenced by political considerations, and for a public department to adopt a foreign invention is to bring down on it an amount of hostile criticism which few governments would be courageous enough to withstand.

We have had notable instances of this in the past; but to those who are acquainted with the manner in which government factories are managed, it needs no recital of examples to show that they move out of established grooves only under the influence of great external pressure. With the incentive towards gain, the proprietors of private works are ready to adopt suggestions that will place them ahead of their rivals; and, therefore, putting aside the labors of the proprietors of the establishment themselves, a member of the staff, or an outside person, bringing forward

a promising suggestion, is eagerly welcomed; that is, of course, supposing there is sufficient competition, as there always should be, in the case of government supplies. On the other hand, the energetic or ambitious subordinate in a government factory knows very well that if he has fresh ideas that will entail thought, hard work, and some responsibility in their working out and adoption, he had better keep them to himself, even if the jealousy of those over him be left out of account.

There is in England no need for a government armor-plate factory. The private firms are quite willing to find all the money and enterprise needed for keeping up the supply, if they are given reasonable encouragement. It is well known that one at least of these firms made an offer some time ago to the Admiralty of increasing their plant to any desired extent, if they were insured a continuance of orders for a very moderate period of time; and other firms, we believe, were quite ready to go on the same lines. Whether it was Treasury obstructiveness, or whether it was some other cause, only those in the confidence of the government could state; but at any rate this reasonable proposal was not entertained. Of late we have been doing better. Vickers's have added a third firm to the big Sheffield armor-plate makers, and Armstrong's have nearly completed a splendid new plant at Openshaw. This will enable the powerful northern firm to make the protective plates for the ships they build with such success at Elswick. At Glasgow, Bardmore's are also capable of turning out certain descriptions of armor.

That these companies should receive encouragement is a matter of national importance. As we have said, there are foreign rivals in the field, and it is, above all, desirable that all fair encouragement should be given to our home makers, to enable them to hold their own. A full volume of trade is the greatest source of strength in the case of a manufacture entailing the laying down of such immensely costly plant, and the employment of highly specialized and exceedingly well-paid labor. The foreign trade we do in ships, guns, and, indeed, all war material is one of our chief sources of military strength, and all legitimate encouragement should be given by the government to this branch of industry, without thought whether the things produced may or may not be turned against us at some future time.

We have said that English makers of armor-plates have made improvements of late, and this fact is well brought out in a paper read last week before the Royal United Service Institution by so good an authority as Captain Orde-Browne. He made reference to the Krupp process, which he says "is no doubt subject to variation, and since it has been adopted in this country, each maker has improved and modified it." As is well known, the English makers, as well as the Americans and French, have all taken licenses from the firm of Krupp. In a table given by Captain Orde-Browne in his paper, results of firing trials at various plates made on the Krupp system are given. From these is seen how notable has been the success of John Brown & Co., the founder of which firm made the first armor-plates in this country, and of the American Carnegie Company. These two firms, which practically are equal, have a better figure of merit for their plates than is credited even to those made by Krupp.

The features of the process are secret, and the secret is well kept, though in so many hands. According to Captain Orde-Browne—although he speaks not without reservation—the process "consists mainly

in the use of chromium to such an extent that great brittleness and hardness might be expected. Sudden cooling is carried out in a way that might be expected to ruin the metal, but the result is great toughness. It must be understood, however, that nickel is also used, and nickel has long been known to give toughness in a remarkable degree."—*Engineering.*

THE NAVY ESTIMATES.

The total net estimates for the coming year reach the imposing figure of 27,522,600*l.*; which is nearly a million more than the estimates for the present year. We give in the table below an abstract of the net estimates on the different votes for the present and preceding five years. This shows very clearly the growth of naval expenditure. It will, of course, be understood that the differences between gross and net estimates are represented by appropriations in aid, and we have, therefore, not considered it necessary to give the gross estimates in our table.

The new programme of shipbuilding provides that there shall be laid down during the coming year two battleships, six first-class armored cruisers, one second-class cruiser, two sloops, two light-draft gunboats, and two torpedo-boats. Of these, the two battleships, two of the armored cruisers, the second-class cruiser, and the two sloops, will be built in the dockyards; so that, putting aside the four boats, only four cruisers are to be given out to contract. Considering the failure of contractors to meet the programme, it was to be expected, and, indeed, inevitable, that the major part of the new construction should be carried out by government establishments. On the whole programme, however, the value of work to be done under vote 8 is almost equally divided between the dockyards and the contractors, the former being allotted construction which is to cost 6,596,000*l.*, while there is to be spent on contract work 6,329,000*l.* The full list of ships that will be in hand is one of considerable magnitude, consisting of no less than 77 vessels of various sizes, of which 17 are battleships and 20 armored cruisers. The other 40 are made up by one first-class protected cruiser, two second-class protected cruisers, one third-class cruiser, eight sloops, two light-draft gunboats, four torpedo-boats, 21 torpedo-boat destroyers, and one Royal yacht. The whole forms a list that would be a respectable navy for most foreign powers; but it is not a ship too many.

As will be seen by our table, five years ago, when the present government came in, the total amount of the navy estimates was 18,700,000*l.* The next year there was an advance of over three millions, next year about half a million, the next year nearly one and a half million, the next year—the present, 2,800,000, and for the coming year the advance, as stated, is not quite a million. If, therefore, we consider the political outlook of the present moment, the estimates now brought forward are certainly moderate, unless those of the past few years have been altogether extravagant. No one considers, excepting a few peace-at-any-price fanatics, that the naval estimates have been excessive. Probably the spending of these extra millions has been the most economical step the nation has ever taken. Large as is the cost of a navy in peace, it is a trifle to that in war.

It will be seen that the largest increase in the estimates is for personnel, the votes for which absorb not far from half the total excess. The num-

TABLE SHOWING NET AMOUNT OF VOTES FOR NAVY ESTIMATES FOR THE COMING AND FIVE PREVIOUS YEARS.

Vote.	Year.	1895-1896	1896-1897	1897-1898	1898-1899	1899-1900	1900-1901
	Effective Services.	£	£	£	£	£	£
1	Wages of officers, seamen, and boys, coastguard, and Royal marines	4,133,500	4,419,800	4,696,000	4,988,000	5,242,700	5,527,000
2	Victualling and clothing for the Navy	1,367,100	1,369,600	1,384,600	1,491,700	1,606,700	1,715,300
3	Medical establishments and service	151,400	156,200	161,400	167,000	176,600	208,800
4	Martial Law	10,600	10,600	10,600	11,400	12,200	13,300
5	Educational services	79,400	81,300	85,600	86,600	90,600	92,300
6	Scientific services	61,400	63,300	66,700	67,200	69,500	66,900
7	Royal Naval Reserves	215,600	229,800	249,900	257,000	271,000	271,100
8	Shipbuilding, repairs, and maintenance:						
	Section I.—Personnel	1,810,000	1,104,000	2,126,000	2,218,000	2,417,000	2,512,000
	" II.—Materiel	2,655,000	2,251,000	2,064,000	2,971,000	3,799,000	4,084,000
	" III.—Contract work	3,416,000	5,386,000	5,440,000	5,612,000	6,601,000	6,329,000
9	Naval armaments	1,698,200	2,543,200	2,775,000	2,549,200	2,710,800	3,004,700
10	Works, buildings, and repairs at home and abroad	547,000	618,400	648,800	650,100	795,100	845,800
11	Miscellaneous effective services	176,800	189,200	195,400	232,900	248,200	271,200
12	Admiralty Office	237,200	236,800	243,600	247,700	261,000	267,100
	Total effective services	16,554,200	19,656,200	19,697,600	21,549,800	24,302,000	25,208,500
	Non-Effective Services.						
13	Half-pay, reserved, and retired pay	761,300	749,000	749,500	752,500	774,700	786,700
14	Naval and Marine pensions, &c.	1,007,900	1,030,100	1,053,200	1,082,900	1,116,000	1,123,600
15	Civil pensions and gratuities	317,300	324,400	327,400	332,900	341,500	343,500
	Total non-effective services	2,086,500	2,103,500	2,130,100	2,168,300	2,232,200	2,253,800
	Extra Estimate.						
16	Additional force in Australasian waters—annuity payable under	60,300	60,300	60,300	60,300	60,300	60,300
	Grand total	18,701,000	21,823,000	22,338,000	23,778,400	26,594,500	27,522,600

ber of officers, seamen, boys, coastguard, and royal marines for the coming year are 114,880; as compared to 110,640 of the present year. With the resources of the country in shipbuilding and engine construction employed to their fullest extent, the question of manning such ships as we have naturally comes to the front. In former years, when the navy was more the shuttlecock of party than at present, personnel received but small attention at the hands of the parliamentarians who ruled in the councils of the nation. The reason was that a big programme of new ships was taken as the criterion of naval progress, no matter whether the vessels were to be manned and gunned or not. The public are better instructed now and have learnt to look more critically at the naval programme.—*Engineering.*

OUR NEW GUNS AND AMMUNITION.

Our manufacture of guns goes on satisfactorily, especially that the new 9.2-inch and 7.5-inch guns will soon be completed, the former for issue, the latter for trial; and further, that the conversion of our 6-inch guns into quick-firers will soon be completed in all ships that are considered worth the expense, and for reserve batteries and drill ships, and that their supply of cordite will be complete at the end of the present year. This is fairly satisfactory. The new guns are very powerful of their type, representing an extreme development of length of bore and high muzzle velocity, and great power of penetration through armor. This type has been developing for many years. England is well represented by these pieces, and England alone has actually in the service any number of guns of wire construction, Russia and America having apparently ceased their efforts in this direction. It will probably seem barbarous and retrograde to object to the form of development which our new type of guns have taken. Without going so far as this, we think that we should guard against being drawn into false directions. These individual guns may be needed; in fact, the 7.5-inch gun is, we think, a necessity in more than one way. That is to say, not only shall we soon need a quick-firing broadside gun of greater power than our 6-inch guns, but the piece must be one of somewhat the actual proportions assigned to the 7.5-inch gun. It must, in fact, have considerably greater penetration than the present 6-inch gun if it is to perforate 6-inch hard-faced armor, while, at the same time, the weight of the projectile must be kept down as much as possible if we are to load and fire quickly. This shuts us up to a small bore, and the gun must be a long one, with high muzzle velocity. We understand that about 3000 foot-seconds is talked of; this, with a 200-pound projectile, gives a muzzle energy of 12,480 foot-tons, with a perforation through 32 inches of iron. This is an enormous result, but we have no hesitation in saying that while the gun is right, so far as it can go, that any one who expects this to be realized on service will be entirely disappointed, because while this velocity may be got perhaps with a new gun, it will rapidly fall with the range, and because the bore of the gun will very soon wear, and thus the muzzle velocity will drop very considerably.

Lieut. Meigs, of Bethlehem, has recently raised the question whether these small bores with high velocities are not an unprofitable form of energy, and we are forced to agree with him. That is to say, velocity in a shot resembles speed in a ship in the fact that we pay very heavily for it in more than one way. On paper, such a gun as this appears admirable.

Considered as a 7.5-inch piece, the results are, indeed, splendid; but this way of taking the calibers as the standard of comparison is misleading. The gun, we are told, will weigh 17 tons, and we have always maintained that the weight of metal represents the capital invested, as it were, and the possible work is proportionate to it. The heaviest 8-inch gun of new type weighs only 15 tons. The old obsolete 10-inch muzzle-loader weighed but 18 tons, with a projectile of more than double the weight of that of the 7.5-inch gun, namely, 410 pounds. The energy was only 5408 foot-tons, but the same metal could now be employed much better with slow-burning powder, and a much better ballistic result obtained. The comparison of what we have in this new 7.5-inch gun with what might be got with a larger projectile, and a muzzle velocity of, perhaps, 2000 foot-seconds, would, be believe, show the latter to be much more profitable and trustworthy, both range and continued firing telling much less against the gun. We may say at once that the alternative is not allowable in this instance, because the larger projectile could not be loaded so fast nor penetrate so much, and we require all the perforating power we can get; 32 inches of iron sounds enormous, but this would not mean more than 10 inches of Krupp process armor and an angle of impact of 30 degrees from the direct line, and the fall of velocity from wear of bore and range would leave us even less margin than we could wish against 6-inch Krupp armor. The fact is that our guns must be made with a view to what we want them to do. As we have repeatedly said, 6-inch hard-faced steel is a most manageable thickness of plate as will be much used in future. The Colon and ships of similar class have been practically covered with such armor, and clearly we must have secondary armaments capable of perforating it even at some sacrifice. This condition does not apply to larger guns. A projectile which cannot perforate the secondary parts of an armor-clad enemy is useless, but the perforation of her belt is quite another matter. A powerful armor-piercing shell in the upper structure might often do more harm than a shot perforating the belt. Lieut. Meigs has recently been engaged in designing and constructing a heavy gun of large bore—namely, an 18-inch gun—whose weight does not differ much from that of our 12-inch wire gun. This piece would have the advantages of preserving its muzzle velocity, which is, we believe, about 2000 foot-seconds as to range, and the bore would wear much less. The bursting charge would be enormous. Against this we have to put the inconveniences of increased weight and bulk of projectiles, both in storage and loading. We need to see this interesting question practically worked out to form any real opinion, and our present point is only to emphasize the fact that our special needs as to perforation have driven our guns to take a wasteful form of energy, and we should be on the watch for any opening to take a profitable departure in a new direction, the possibility of which seems at present confined to our larger guns, and we should think specially the larger guns of our cruisers.

The conversion of all our secondary armament guns to quick-fire action is of great importance, and a good system of conversion having been arrived at, it is satisfactory to know that it will be completely carried out before long. Cordite is a special element in our system; it may be questioned if it is very satisfactory in the face of the tremendous rate at which our guns wear out. A few weeks since, we noticed the fact of our steel being slightly softer than that generally used on the continent. A much more important matter is the nature of our powder. All smokeless

powders consist largely of guncotton, on which account we ought to pay a passing tribute to Austria and Baron Lenk. Guncotton requires the addition of an oxidizing ingredient—nitroglycerine being used by Germany, ourselves and others; and nitrate of baryta by Russia and the United States. The former offers the advantage of complete action, the whole of the products of combustion being gas. The latter is only semi-smokeless, and its incomplete action prevents the full development of power, but it is said to injure the bore very much less than the nitroglycerine powders, especially cordite, which contains much the largest proportion. We state the case as it is put; we are not aware of any trustworthy results obtained by comparative trials of powders. It is claimed for cordite that its erosion is remarkably even, and we know that much can be done to prevent it by special gas checks. The whole matter, however, cannot be said to be satisfactorily worked out, and it is well that we should recognize it and keep our eyes open.

As regards projectiles, in the present state of things, a good armor-piercing shell is the projectile most needed, and we may congratulate ourselves on having one. Ships will probably depend more on their heavy quick-firing batteries than on other guns; while we have 6 inches of hard-faced armor in front of the secondary armaments in our strongest ships, nearly all foreign ships have very inferior protection, so that, on the whole, we have much upon which to congratulate ourselves at the present time.—*The Engineer.*

BRITISH AND FRENCH GUNS.

Sir Charles Dilke's question in the House as to the relative powers of British and French guns has served to stimulate the misgivings which many feel as to the condition of our ordnance, though the question is here raised in a new form, since it is our heavy guns that are declared to be inferior to those of France. We fear that the First Lord's answer was calculated to foster uneasiness. When a question is asked with proper notice, a definite reply is expected. Sir C. Dilke said that "the figures quoted with regard to the French guns went to show their superiority over our own guns at every period of the shot." "Mr. Goschen thought that this was doubtful." Consequently, at best, any one fully accepting his statement can only "think doubtfully" with him. Now we are not prepared to say that a very exactly certain answer can be given, but, at all events, it is desirable to show that the scope of uncertainty is narrow, and that if there exist elements that need to be improved, improvement is not difficult of achievement, and this, we think, can be shown. Indeed, we may say at once that while we think that serious attention ought to be given to the ballistic conditions of our heavy guns and their charges, there is nothing wrong that cannot be rectified, and that in some essentials British guns are the very best. We have dealt with some elements in this question lately, but it may be well to review the matter again briefly. First, let us deal with the actuals guns themselves. The proportions of guns have been calculated for so many years, that little new can be put forward. The French certainly keep the details of their new guns as secret as possible, nevertheless no uneasiness need be felt where no surprise is conceivable. Guns achieve higher velocity as years go by, because they are made longer and heavier in proportion to their caliber. The chamber may vary in size to suit special charges, but in

actual proportions the possibilities are mainly limited to obtaining an increase of velocity if we like to pay for it in the shape of increased length and weight.

The result, however, is sometimes proved to be undesirable. A few years since, very long guns for coast service were advocated by M. Canet. In the table in the *Naval Annual* for 1899 may be seen pieces 80 calibers in length. We happen to know that these have disappeared from the tables of Schneider-Canet guns for the coming number, so that this clearly illustrates our point, namely, that there is no magic in the metal structure of a gun; that any good maker can produce a gun of increased power by giving it increased length and weight; but, like our own 111-ton gun, it may be a white elephant, whose room is preferable to its company. When we say that all metal is the same, we are not speaking absolutely correctly; there is a little, although very little, difference between one and another gun steel; and much more, there is a substantial advantage which we claim in the wire or riband construction. This might be sufficient to take seriously into account, were it not that owing to reasons to be noticed presently, we are unable to avail ourselves of it. On the whole, our readers may be satisfied that as regards the actual metal the guns themselves are good, and that no surprises can await us and show us that we need new pieces. This is, at all events, satisfactory, as it means that our main provision in the way of ordnance is sound.

Guns and caliber in inches.	Length in calibers.	Weight of gun in tons.	Weight of projectile in pounds.	Muzzle velocity foot-seconds.	Muzzle energy foot-tons	Energy at 2000 yards—foot-tons	Muzzle energy per ton of gun.
British 12.....	40	50	850	2600	33,020	29,860	660.4
French 12.....	40	45.9	643.8	2625	30,750	21,020	669.9
British 9.2.....	46.74	27	380	2600	17,810	12,130	660.0
French 9.45.....	40	22.4	317.5	2625	15,170	9,354	676.2
British 6.0.....	45	7.4	100	2642	4,840	2,612	654.1
French 6.46.....	45	6.89	99.21	2625	4,730	2,302	686.5
United States, new, 12...	40	52	850	2800	46,246		889.3

We must next pass on to the elements of power and projectile. For more complete comparison we give herewith a short table of the three pairs of British and French guns that seem the best and fairest representatives, namely, those of 12-inch, 9.2 inch and 9.45-inch, and lastly 6-inch and 6.46-inch caliber. We admit, as we have said, that there may be newer French designs, but these are the best available. It will be seen that our 12-inch guns are the same length. Ours weighs 50 tons and the French gun 45.9 tons. Our muzzle velocity is given as about 2600, and the French as 2625 foot-seconds. Now both these velocities are estimates, and in such estimates 25 foot-seconds difference is accidental, the fact being that the numbers are round in each case, and the French 800 meters which is given for each French gun in this table happens to be equivalent to 2625 feet in British units. Several French guns may be seen estimated to the same round number, 800 meters, in fact, all the three in these tables. The first comment to be made is that our guns appear to be unnecessarily heavy, but this is explained by the weight of projectile; ours weigh 850 pounds, and the French only 643.8 pounds, so that our gun has a muzzle

energy of 33,020 against 30,750 foot-tons in the French gun. As the range increases the weight tells more, so that at 2000 yards it may be seen our projectile has 29,860, and the French one only 21,020 foot-tons energy, so that our superiority has increased from about 10 per cent to 42 per cent. The same difference is seen throughout. In each case the British guns and projectile are the heavier, and the French muzzle velocity the higher. At the muzzle, the energy per ton of gun is greater in the French shot, but at 2000 yards our projectiles have overtaken them; thus, with the 12-inch we have 597 against the French 458. In short, judging from the British and French guns in this table alone, we should say that we have no cause for complaint, and that however diffidently expressed, Mr. Goschen was right in his statement that we had the advantage at the end of the trajectory, while Sir Charles Dilke was wrong in saying that any attainable figures go to "show superiority at every period." Even at the muzzle, our shot have greater energy, so that Sir Charles Dilke's statement is literally the reverse of the truth, unless he takes the less weight of the French guns into account, which is a different question. Even so, all that can be said is that the French get rather more work per ton of gun at the muzzle, but lose this advantage even at a short range.

Having thus made out, we think, a fair case for our guns, we shall perhaps surprise our readers by saying that it is by no means the whole case, and that elements exist which force us to the conclusion that we need seriously to reconsider certain matters, though they are points not touched on in the House. It may be seen that at the foot of the table we have added a United States 12-inch gun of new design. It is not found in existing tables, but we have the figures on the best authority, that is, from the United States Bureau of Ordnance. In some respects this gun should be satisfactory to us. It may well have been copied from our own. The length is the same, so is the weight of projectile. The gun is two tons heavier. Possibly ours being of wire construction, may be as strong, so that in the actual metal there may be little to choose, or rather we may have the advantage. But now comes the point. The American gun claims 2800 foot-seconds velocity, against our 2600 foot-seconds, and this opens the question that we think calls for inquiry—the question of powder. In tables generally foreign guns will be seen claiming higher velocities than ours. There might not be much stress to be laid on this, because new guns always have high velocities, and we have already pointed out that in many cases they are estimated velocities only. Unfortunately many of us are aware that whatever foreign guns do, our own wear at a rate which causes the velocity to fall shockingly fast. As has before been said, our heavy guns go to sea with a supply of ammunition which, limited though it is, could not be fired away without the velocity and shooting of the piece falling off seriously. We doubt if all the devices in the way of gas-checks and augmenting strips of copper would carry some guns satisfactorily through 100 rounds. We are met by the statement, and we believe it is true, that no nation, except perhaps the United States, fire their guns much in peace time, consequently it is argued that their guns are not forcing this said fact of wear on their owners, simply because wear is not taking place. Nevertheless it is surely mad to assume that because we experience an evil, our neighbors, whose conditions differ substantially from ours, must necessarily suffer the same evil and to the same extent. All we know is that they do not own to it. Let us consider how we stand in the matter of powder and wear of bore. The wear has been

classified under two heads, " erosion " and " wash." Erosion is the eating out of the surface of the bore by the charge pure and simple. Wash is the rush of gas between two surfaces, that is, between projectile and bore, whenever a space is found. Erosion is due to gas moving rapidly at a very high temperature, and, of course, under pressure, although the latter need not be high. Thus, erosion is not found to be serious in the powder chamber, because, although the temperature is high, the gas is not in rapid motion. It is not serious in the forward part of the bore, because, although in rapid motion, the temperature has become considerably reduced. About the seat of the shot and a few calibers beyond it the action is, we repeat it, frightful. Wash can be remedied to a great extent by means of tight-fitting gas-checks, and, as the bore gets enlarged, by augmenting strips of copper. The evil is serious enough, but erosion is the parent of wash, and erosion is the evil to be specially grappled with. It will be found that we use powder of a very different character from other nations, that is, cordite. Surely, matters standing as they do, we ought to put cordite on its trial again, not necessarily as to its behavior in small pieces, but certainly it should be brought up on the charge of wearing out the bores of our heavy guns in an unprecedented manner. If the same thing is going on with our neighbors' powder, we may consider it eventually a necessary evil besetting the use of smokeless powder to obtain very high velocities; but we ought to make sure that this is so before we " sit down " under such a conclusion. We have said that we use very different powder from other nations. Let us see how the matter stands.

We have all adopted powder more or less smokeless, and the foundation of such powder is, we believe, in every case guncotton. This requires an oxidizing agent to consume it completely, and the one that most readily does so is nitroglycerine. Some, however, not unnaturally prefer to avoid the use of nitroglycerine—partly, perhaps, because, unless completely taken up in a stable compound, it is excessively dangerous. This evil, however, appears to have been got over. It has, further, the reputation of causing great erosion. Consequently Russia and the United States have hitherto vetoed it altogether, using nitrate of barium, or other substitute, with guncotton. The result is said to be that their powder is only semi-smokeless, and the products of combustion are not all gaseous, so that there is waste of energy in discharging them. France uses powder of somewhat the same kind. Germany uses, we believe, about 25 per cent. of nitroglycerine. We use cordite containing, according to the official book, 58 per cent of nitroglycerine. Before adopting cordite, we subjected it to severe trial, and found that it bore the changes of temperature and exposure to the climatic influences that England, most of all powers, has to contemplate. There is also much to recommend it as to practical convenience. Nevertheless, we think that a *prima facie* case exists for trial in comparison with other powders for charges of heavy guns.

In writing this, we feel that it is quite possible that cordite may turn out to be no worse than its rivals. Sir Andrew Noble, whose opinion should carry more weight than that of any one we could name in this country, has always thought well of cordite, and manufacturers seem to like it. Nevertheless, we would in conclusion repeat the gist of the question as it appears to us. We know that our heavy guns wear so intolerably fast that we cannot reckon on the velocities we assign to them for any considerable number of rounds. We know that their shooting

falls off rapidly. We use charges that bear no relation to the strength of our wire guns, at all events in many cases. We know also that other nations will not contemplate cordite, but use powders of widely different character, and do not complain of wear of bore to the same extent as ourselves. We, therefore, think that we ought to test our cordite carefully in comparison with other powders, especially having our heavy guns in view—guns in which, it may be observed, the absence of smoke is of less and less importance as the gun increases in size and its rate of firing becomes less.—*The Engineer.*

THE MARCONI WIRELESS TELEGRAPH INSTALLATION ON BOARD THE NORTH GERMAN LLOYD'S S. S. KAISER WILHELM DER GROSSE.

This, the first merchant steamer to receive a permanent equipment of wireless telegraph, sailed from Bremenhaven February 28, 1900, on her regular trip, touched at Southampton and Cherbourg on the first of March, and arrived at New York on the 7th instant.

The apparatus is almost an exact reproduction of those tested by the bureau last fall on the U. S. S. New York, Massachusetts and Porter, and described in the report of the Marconi board.

The choking coils and cells of the local battery are enclosed in neat wooden boxes.

Various binding posts and fittings are solidly constructed and neatly finished.

The connections to the back-stop of the key for automatically connecting up the receiver are substantially made and are used right along.

The vertical wire is double; *i. e.*, a bight is triced up to the sprit-end and one leg is spliced into the other just before it passes through the top of the deck-house.

An umbrella-shaped sheet of ebonite protects the tube through which the wire is led into this operating-room.

An improved form of cylindrical ebonite insulator is used, having a small strand of seizing wire cemented in each end.

Two substantial wooden posts secured to the forward corners of the deck-house take the strain of the wire which is led midway between them.

No wooden topmast is used, the sprit, about 20 feet long, hoisting to the truck of the steel pole mast, giving an effective height of vertical wire of about 100 feet.

The shore station on the Isle of Borkum, off the mouth of the river Ems, had a vertical wire of 150 feet height.

Messages were received on board the ship 40 miles from this station, and were received at the shore station when the ship was 50 miles away.

An outfit had been sent on board the Borkum Lightship, but owing to the heavy weather the wooden topmast had not yet been secured aloft when the Kaiser Wilhelm passed. This lightship is to have a vertical wire of 130 feet height.

The Marconi operator left the ship at Southampton and is to board her there on her return. In the meantime, an operator in the employ of the steamship company is taking care of the apparatus and learning to operate it.

The first officer of the Kaiser Wilhelm Der Grosse stated that the

apparatus had worked without a hitch and communication was not interrupted while the ship was in range of the shore station.

THE DESTROYER BAT.

A serious mishap, fortunately unaccompanied with loss of life, took place on board the torpedo-destroyer Bat on February 21. She was engaged on instructional class duty. The instructional classes have a course of four weeks, the first three weeks consisting of runs at gradually increasing speeds, culminating in one hour's run at top speed. In the case of the Bat, this full-power run was in course of being carried out. Everything was apparently going well, the hour was nearly up, the engines were making 360 revolutions and the boat was travelling at 28 knots. A loud noise was then heard, followed by an escape of steam. Steam was promptly cut off and the eight occupants of the engine-room at the time succeeded in getting on deck without injury. The starboard engine was found to be badly damaged, and the Bat returned to Devonport with the port engine only. On further examination, it is stated that the prime cause can be traced to the cap of the low-pressure crosshead brasses, which fractured across one of the bolt holes. This fracture freed the connecting-rod, which knocked against, and badly bent, the crosshead guide, and made a bulge in the condenser. The piston being also free, was forced up and broke the cylinder cover, at the same time badly cracking the cylinder. It is certainly wonderful, seeing what happened, that no injuries were sustained by any of the men in the engine-room. As it was, there was a rush of steam, which promptness on the part of someone stopped by closing the main steam valve. Had it been in connection with the high-pressure cylinder, one trembles to think what might have happened. We know what took place in connection with the Bullfinch. We understand that an inquiry is to be instituted into the cause of the accident, and we therefore, for the present, refrain from commenting upon it.—*The Engineer.*

A terrible accident, says the *Army and Navy Gazette*, has taken place in the French torpedo-boat No. 228, under command of Lieutenant Pioger. She is a new boat built by the Forges et Chantiers de la Méditerranée, and was under trial at the time. A great part of the programme had been gone through at Cherbourg, a speed of 25½ knots having been attained, and the engineers were full of satisfaction, for the French Admiralty was to give a bounty of 20,000f. for every half-knot above the contract speed. All at once there was a violent shock, and the stokehold and boiler-room were filled with steam. A piston-rod had broken and the cylinder cover had given way. Five men were very seriously scalded and many in lesser degree.

The deepest ocean temperatures which have been recorded were taken by the United States steamer Nero, which is sounding for the cable between Guam and the Midway Islands. At a depth of 30,420 feet the water had a temperature of 35.9 degrees Fahr., and at 9060 feet it was 36 degrees Fahr.

At the present moment the Bat is laid up. Half her consorts are in the same plight, owing to one having broken adrift in a gale and smashed into the others. The Teaser, at Portsmouth, has 6 inches nipped off her bow. The Hunter, which had her bow neatly doubled back some months ago, is still in basin at Portsmouth in that condition. It has, so far, not been deemed worth while to repair her.—*The Engineer.*

In the matter of coaling, the French Admiralty is in marked contrast to our own. Every British ship of size carries a Temperley, but the matter pretty well ends there; there are rarely winches to work them properly, so that the ship is dependent on the collier, and often has to resort to hand-power from lack of means to properly use its Temperleys. This is notably so in the Royal Sovereign class: but the commanders and engineer officers of the Majestic class have vainly asked for extra winches for years. Of course, our principle of always doing a thing by hand-power if possible, is very fine in its way; but like all good things, it can be abused. And in war time every extra minute spent in coaling ships would be important, possibly of deadly moment. Moreover, seeing the strain that watching for torpedo-boats will cause every night, it is imperative that labor when in harbor should be reduced to the absolute minimum. Consequently in peace time everything should be done to facilitate coaling by the most expeditious and least laborious means, for it is very certain that such cannot be extemporized in war time, and the theory that the dockyard people will do the coaling is all theory. They will be far too busy over repairs, nor will there be any spare men at the depots. Yet, despite all this, we proceed in a most casual fashion, and the whip is the real mainstay of coaling.—*The Engineer.*

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The book should be of especial value to the officers of the volunteer army.

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A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1901. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute. If the essayist second in order of merit receive "Honorable Mention," he will also be made a life member.

The prize essay for 1899 was won by Lieut. R. H. Jackson, U. S. N., the title of the prize essay being "Torpedo Craft: their Type and Employment." Lieut. L. H. Chandler, U. S. N., received Honorable Mention for an article entitled "The Automobile Torpedo and its Uses," and was made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of the Board of Control.

R. H. JACKSON,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *June 1, 1900.*